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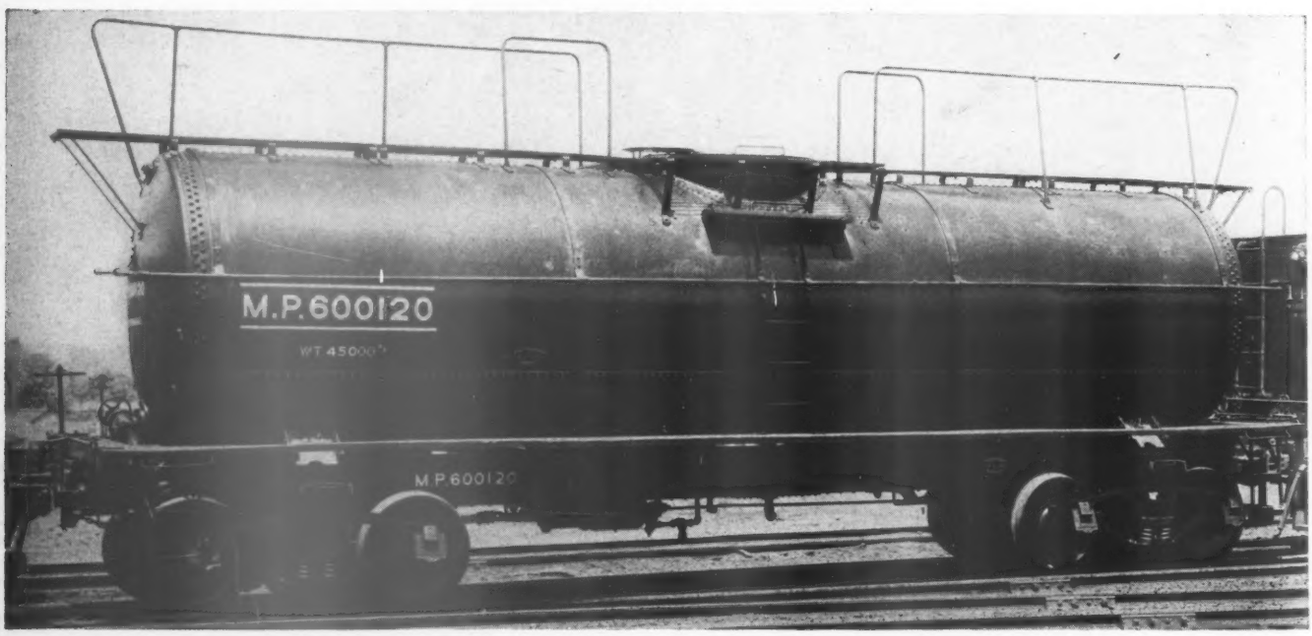


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Published monthly by Simmons-Boardman Publishing Corporation, 1309 Noble Street, Philadelphia, Pa. Entered as second-class matter, April 3, 1933, at the Post Office at Philadelphia, Pa., under the act of March 3, 1879. Subscription price, $3.00 for one year, U. S. and Canada. Single copies, 35 cents. Vol. 118, No. 5.

# RAILWAY MECHANICAL ENGINEER

*(Name Registered, U. S. Patent Office)*
*With which is incorporated the RAILWAY ELECTRICAL ENGINEER.*

**Founded in 1832 as the American Rail-Road Journal**

## MAY, 1944

*Volume 118* — *No. 5*

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Published on the second day of each month by
**Simmons-Boardman Publishing Corporation**

SAMUEL O. DUNN, *Chairman of Board, Chicago;* HENRY LEE, *President, New York,* ROY V. WRIGHT, *Vice-Pres. and Sec., New York,* FREDERICK H. THOMPSON, *Vice-Pres., Cleveland;* ELMER T. HOWSON, *Vice-Pres., Chicago;* FREDERICK C. KOCH, *Vice-Pres., New York;* ROBERT E. THAYER, *Vice-Pres., New York;* H. A. MORRISON, *Vice-Pres., Chicago;* J. G. LYNE, *Vice-Pres., New York;* H. E. MCCANDLESS, *Vice-Pres., New York;* JOHN T. DEMOTT, *Treas. and Assist. Sec., New York.*

*The Railway Mechanical Engineer is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. B. C.), and is indexed by the Industrial Arts Index and also by the Engineering Index Service.* PRINTED IN U. S. A.

1309 Noble street, Philadelphia, Pa. Editorial and Executive Offices: 30 Church street, New York 7, and 105 West Adams street, Chicago 3. Branch offices: Terminal Tower, Cleveland 13; 1081 National Press bldg., Washington 4, D. C.; 1038 Henry bldg., Seattle 1, Wash.; 300 Montgomery street, Room 805-806, San Francisco 4, Calif.; 560 W. Sixth street, Los Angeles 14, Calif.

Subscriptions, payable in advance and postage free, United States, U. S. possessions and Canada: 1 year, $3; 2 years, $5. Foreign countries: 1 year, $4; 2 years, $7. Single copies, 35 cents. Address H. E. McCandless, circulation manager, 30 Church street, New York 7.

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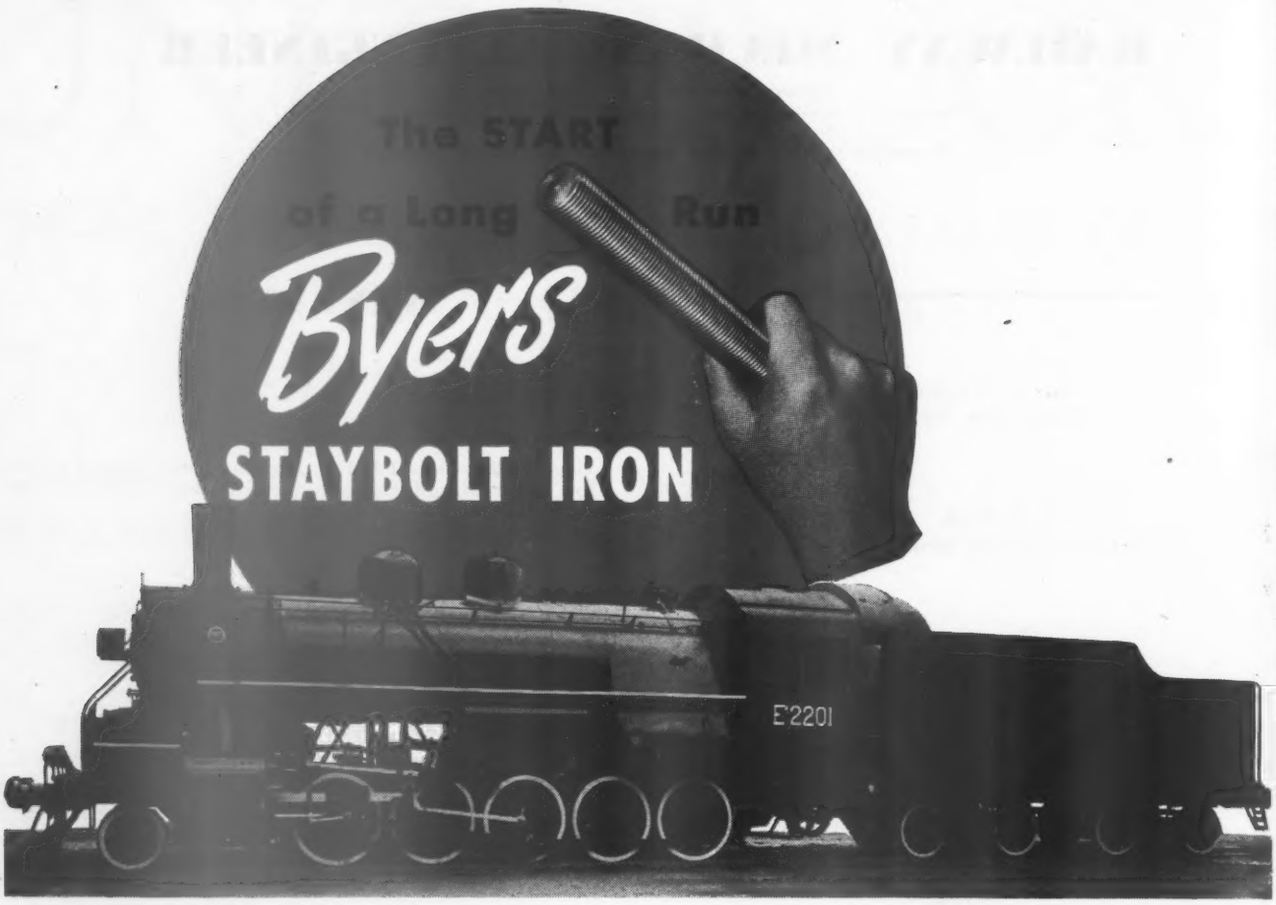


This locomotive is starting on a run that will take it hundreds of miles on a flat car . . . thousands of miles on a ship . . . and finally hundreds of thousands of miles under its own power. It is one of a number built by Baldwin for Russia. The 5-foot gage makes the auxiliary transport necessary.

These locomotives are well equipped for a long run, so far as one important item is concerned: the staybolts are made of Byers Staybolt Iron. This material has been extensively used on export locomotives. Its durability and dependability have been verified by millions of locomotive-miles over American trackage.

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**Lehigh Valley Class T2b**

# Fast Freight Locomotives

WITH the acquisition of ten 4-8-4 type fast freight locomotives built by the American Locomotive Company, the Lehigh Valley now has a total of 37 Class T motive power units. The most recent of these to be placed in service are known as road class T2b and bear the numbers 5211-5220. Like their predecessors the T2's, built by the same builder in 1931 and 1932, they have a rated tractive force of 66,700 lb., 6-in. by 32-in. cylinders, 70-in. drivers and 255 lb. boiler pressure.

Descriptions of the first locomotives of this type appeared in the *Railway Mechanical Engineer* for May, 1931, page 237 and April, 1935, page 133. In the design of all of these locomotives, interchangeability of parts with previous orders has been a major consideration although, as compared with the original T2's the present group incorporates several minor refinements in design.

## The Boiler

The boilers on these locomotives are of the conical design for 255 lb. steam pressure. Carbon steel sheets are employed for both shell and firebox. The barrel seams are butt-joint multiple riveted and welding has been employed extensively in the construction of the firebox. The crown and furnace sides are in one piece which is welded to the furnace-door sheet, furnace throat sheet and combustion chamber. The fireboxes have an extensive installation of Flannery flexible staybolts in the throat sheet, combustion chamber, back head and the breaking zones of the firebox. The boilers are equipped with three 3-in. safety valves, the Elesco Type E 102-unit superheater and American multiple throttle in the superheater header. Water is fed to the boilers through the medium of a Worthington 5½ SA feedwater heater having 10,200 gal. capacity and one Edna Type FNL 14,000-gal. injector on the left side.

The dimensions and proportions of these boilers are shown in Table II and the accompanying boiler diagram.

## Foundation and Running Gear

The foundation of these locomotives consists of a General Steel Castings Corporation cast-steel bed with cylinders, back heads, cradles, air-compressor brackets and main reservoirs cast integral. Ex-Cell-O bushings are used in the bed for the spring rigging and brake-hanger pins as well as in the hangers and equalizers. The cylinders and valve chambers are fitted with Hunt-Spiller bushings. The crossheads are the multiple bearing type and the driving rods are rectangular section, of medium carbon steel, with solid-end main rods. These

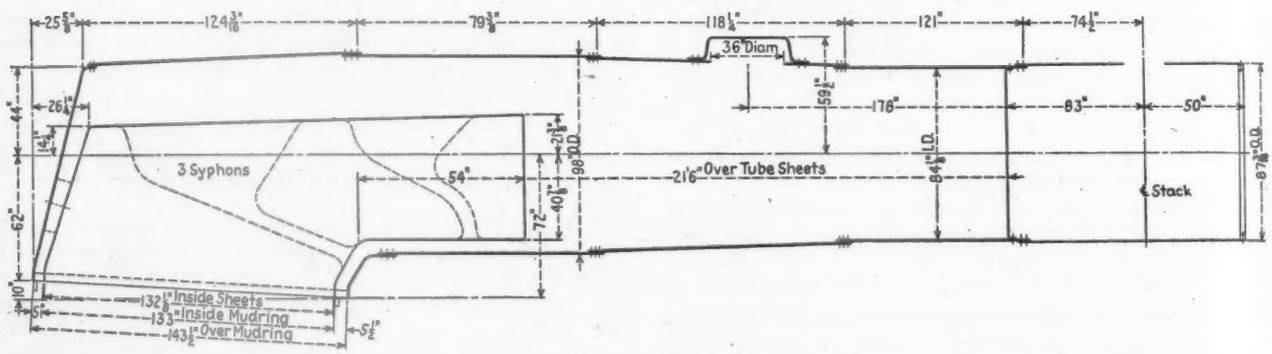
**Ten additional units, built by Alco, bring total of this type on that road to 37-New locomotives weigh 451,000 lb. with 66,700-lb. tractive force**

## Table I — General Characteristics, Dimensions, Weights and Proportions of the Lehigh Valley Locomotives

(For corresponding data relating to boiler see Table II)

| | |
|---|---|
| Road class | T2b |
| Road number | 5211—5220 |
| Builders order number | S-1904 |
| Date built | November, 1943 |
| Steam pressure, lb. per sq. in. | 255 |
| Drivers, diameter, in. | 70 |
| Cylinders, number, diameter and stroke, in. | 2—26 x 32 |
| Rated tractive force, engine, lb. | 66,700 |
| Rated tractive force, booster, lb. | 12,300 |
| Valve gear, type | Baker |
| Valves, piston, diameter, in. | 12 |
| Maximum travel, in. | 8⅝ |
| Steam lap, in. | 1⅜ |
| Exhaust clearance, in. | ⅛ |
| Lead, in. | 5/16 |
| Cut-off in full gear, per cent | 82 |
| Dimensions: | |
| Height, rail to top of stack, ft.-in. | 16—0 |
| Height, rail to center of boiler, ft.-in. | 10—7½ |
| Width overall, ft.-in. | 10—10 |
| Length over engine and tender, ft.-in. | 108—6⅛ |
| Cylinder centers, in. | 92 |
| Wheel bases, ft.-in.: | |
| Driving | 19—3 |
| Rigid | 6—5 |
| Engine, total | 45—7 |
| Engine and tender, total | 95—0 |
| Weights, lb.: | |
| Front truck | 72,500 |
| Drivers | 274,500 |
| Trailer truck | 104,000 |
| Engine, total | 451,000 |
| Tender (2/3 loaded) | 304,400 |
| Weight on drivers, per cent weight of engine | 60.8 |
| Weight on drivers ÷ tractive force | 4.11 |
| Tender: | |
| Style or type | Rectangular |
| Water capacity, U. S. gal. | 20,000 |
| Fuel capacity, tons | 30 |
| Trucks | six-wheel |

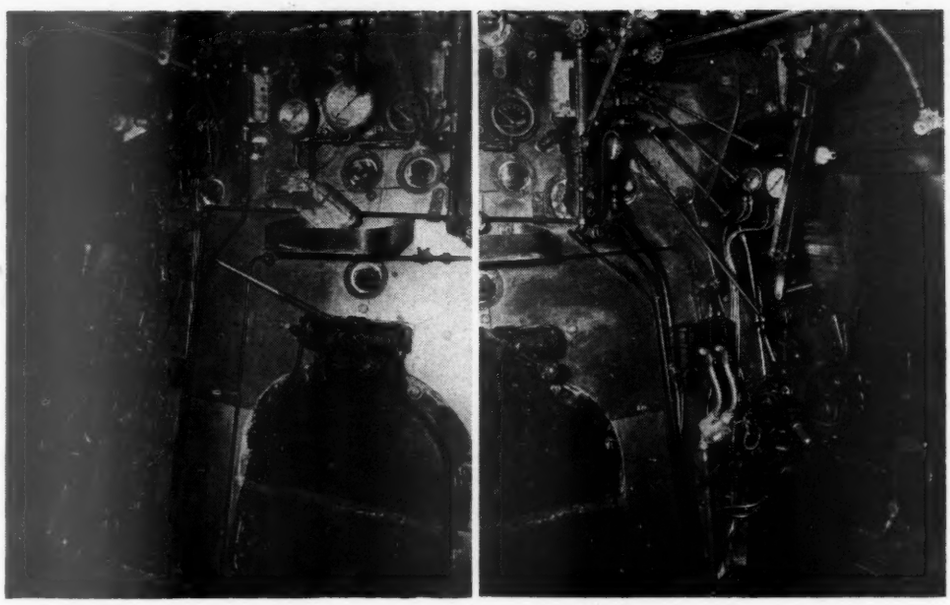
## Table II—General Dimensions and Portions of the Boiler




| | |
|---|---|
| Steam pressure, lb. | 255 |
| Diameter first ring, inside, in. | 84¼ |
| Diameter first ring, outside, in. | 86-3/16 |
| Diameter second ring | Conical |
| Diameter third ring, inside, in. | 95-13/16 |
| Diameter third ring, outside, in. | 98 |
| Sheet thicknesses, in.: | |
| Smokebox | ½ |
| First ring | 31/32 |
| Second ring | 1-3/32 |
| Third ring | 1-3/32 |
| Back head | ½ |
| Side sheets | ½ |
| Roof sheet | 1-3/32 |
| Furnace door sheet | ⅜ |
| Furnace side sheets | ⅜ |
| Furnace crownsheet | ⅜ |
| Combustion chamber | ½ |
| Front tube sheet | ⅝ |
| Back tube sheet | ½ |
| Flexible staybolts, number and location: | |
| Throat sheet | 125 |
| Back head | 266 |
| Side sheets | 1,132 |
| Combustion chamber | 424 |
| Firebox length, in. | 132⅛ |
| Firebox width, in. | 96¼ |
| Water space, front, in. | 5½ |
| Water space, back, in. | 5 |
| Water space, sides, in. | 5 |
| Combustion chamber length, in. | 54 |
| Arch tubes, number and diameter | None |
| Syphons, number and location | 3—firebox<br>1—combustion chamber |
| Tubes, number and diameter | 73—2¼ |
| Tubes, thickness (B. W. G.) | 11 |
| Flues, number and diameter | 202—3½ |
| Flues, thickness (B. W. G.) | 11 |
| Length over tube sheets, ft.-in. | 21—6 |
| Net gas area through tubes and flues, sq. ft. | 9.97 |
| Superheater, type | E |
| Fuel | Bit. coal |
| Grates, type | Firebar rocking |
| Grate area, sq. ft. | 88.3 |
| Stoker, type | Standard HT |
| Feedwater heater, type | Worthington 5½ SA |
| Heating surfaces, sq. ft.: | |
| Firebox and combustion chamber | 363 |
| Arch tubes | None |
| Syphons | 131 |
| Firebox, total | 494 |
| Tubes | 920 |
| Flues | 3,962 |
| Evaporative, total | 5,376 |
| Superheating | 2,095 |
| Comb. evap. and superheat. | 7,471 |
| Boiler proportions: | |
| Firebox heat. surf., per cent comb. heat. surf. | 6.6 |
| Tube-flue heat. surf., per cent comb. heat. surf. | 65.4 |
| Superheat. surf., per cent comb. heat. surf. | 28.0 |
| Firebox heat. surf. ÷ grate area | 4.95 |
| Tube-flue heat. surf. ÷ grate area | 53.3 |
| Evap. heat. surf. ÷ grate area | 60.8 |
| Superheat. surf. ÷ grate area | 23.7 |
| Comb. heat. surf. ÷ grate area | 84.6 |
| Gas area ÷ grate area | 0.113 |
| Tractive force ÷ grate area | 755.0 |
| Weight of engine ÷ evap. heat. surf. | 83.9 |
| Weight of engine ÷ comb. heat. surf. | 60.3 |
| Tractive force ÷ evap. heat. surf. | 12.4 |
| Tractive force ÷ comb. heat surf. | 8.9 |
| Tractive force × diameter drivers ÷ comb. heat. surf. | 624.9 |

## Table III—Axles, Bearings, Wheels and Tires

| | Axles | | | | Wheels or Tires | | | Wheel Centers | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Location | Material | Manufacturer | Bearings | Journal, size, in. | Type and material | Manufacturer | Diameter | Type | Manufacturer | Diameter, in. |
| Front truck | Open hearth steel | Carnegie-Illinois Bethlehem | Timken | 7 x12 | Heat-treated carbon, multiple wear | Carnegie-Illinois Bethlehem | 33 | ..... | ..... | .. |
| Drivers, main | Open hearth steel | Carnegie-Illinois Bethlehem | Plain | 13 x 14 | Open-hearth steel | Midvale Co. | 70 | Boxpok | General Steel Castings | 62 |
| Drivers, other | Open hearth steel | Carnegie-Illinois Bethlehem | Plain | 11 x 14 | Open-hearth steel | Midvale Co. | 70 | Boxpok | General Steel Castings | 62 |
| Trailer, front | Open hearth steel | Carnegie-Illinois Bethlehem | Timken | 7 x 14 | Heat-treated carbon, multiple wear | Carnegie-Illinois Bethlehem | 36 | ..... | ..... | .. |
| Trailer, rear | Open hearth steel | Carnegie-Illinois Bethlehem | Timken | 9 x 14 | Open-hearth steel | Midvale Co. | 45 | Cast steel | ..... | 38 |
| Tender | Open hearth steel | Carnegie-Illinois Bethlehem | Timken | 6½ x 12 | Heat-treated carbon, multiple wear | Carnegie-Illinois Bethlehem | 36 | ..... | ..... | .. |



rods have fixed bushings in the front end and floating bushings at the main crank pin.

The type and material of the axles, bearings and wheels for both engine and tender, are shown in Table III.

The driving boxes for the four driving axles are cast steel fitted with Magnus bearings and Hennessey lubricators. The Alco lateral motion cushioning device is used on the front and rear wheels.

The engine truck is a General Steel Casting Corporation's four-wheel inside-bearing type having a swing of 5¾ in. each side of the center. The four-wheel trailer

(*Continued on page 206*)

## Partial List of Materials and Equipment on the Lehigh Valley 4-8-4 Type Freight Locomotives

| | |
|---|---|
| Engine bed; engine and trailer truck; bumpers | General Steel Castings Corp., Eddystone, Pa. |
| Engine-truck, trailer truck and tender-truck roller bearings | The Timken Roller Bearing Co., Canton, Ohio. |
| Adjustable wedges; radial buffer | Franklin Railway Supply Co., Inc., New York. |
| Springs | Railway Steel Spring Div., American Locomotive Co., New York. |
| Pilot coupler | National Malleable and Steel Castings Co., Cleveland, Ohio. |
| Drawbar | Ewald Iron Co., Louisville, Ky.<br>Franklin Railway Supply Co., Inc., New York. |
| Brake equipment | Westinghouse Air Brake Co., Wilmerding, Pa. |
| Brake rigging; spring-rigging pins and bushings | Ex-Cell-O Corporation, Detroit, Mich. |
| Train control | General Railway Signal Co., Rochester, N. Y. |
| Air pump packing | Durametallic Corporation, Kalamazoo, Mich. |
| Pistons; piston rings | Locomotive Finished Material Co., Atchison, Kans. |
| Piston-rod and valve-stem packing | U. S. Metallic Packing Co., Philadelphia, Pa. |
| Valve gear | Pilliod Co., New York. |
| Power reverse gear; lateral motion device; staybolts | American Locomotive Co., New York. |
| Bearings; driving boxes, eccentric rods and main and side rods | Magnus Metal Div., National Lead Co., New York. |
| Bushings — cylinder and valve; valve packing rings | Hunt-Spiller Manufacturing Corporation, Boston, Mass. |
| Booster | Franklin Railway Supply Co., Inc., New York. |
| Mechanical lubricators; flange oiler shoes | Detroit Lubricator Co., Detroit, Mich. |
| Oil dividers; injectors; boiler checks | Edna Brass Mfg. Co., Cincinnati, Ohio. |
| Lubricator tubing | Bundy Tubing Co., Detroit, Mich. |
| Grease fittings | The Prime Manufacturing Co., Milwaukee, Wis. |
| Driving-box lubricators | Hennessey Lubricator Company, Inc., New York. |
| Boiler and firebox steel | Bethlehem Steel Co., Bethlehem, Pa. |
| Boiler tubes | Jones & Laughlin Steel Corp., Pittsburgh, Pa.<br>National Tube Co., Pittsburgh, Pa. |
| Boiler rivets | Republic Steel Corp., Massillon, Ohio. |
| Staybolts | Flannery Bolt Co., Bridgeville, Pa. |
| Staybolt iron | Joseph T. Ryerson & Son, Inc., Chicago. |
| Superheater pipes | Pittsburgh Steel Co., Pittsburgh, Pa. |
| Superheater | The Superheater Company, New York. |
| Syphons | Locomotive Firebox Co., Chicago. |
| Arch | American Arch Co., Inc., New York |
| Boiler drop plugs; water gage; gage cocks | Nathan Manufacturing Co., New York. |
| Blowoff cock and muffler | The Okadee Company, Chicago. |
| Lagging | Johns-Manville Sales Corp., New York. |
| Pipe covering | Union Asbestos & Rubber Co., Chicago. |
| Throttle valve | American Throttle Co., New York. |
| Feedwater heater | Worthington Pump and Machinery Corp., Harrison, N. J. |
| Blower nozzles | Barco Manufacturing Co., Chicago. |
| Valves and cocks | Edna Brass Mfg. Co., Cincinnati, Ohio.<br>The Lunkenheimer Company, Cincinnati, Ohio.<br>Walworth Company, New York. |
| Stoker | Standard Stoker Co., Inc., New York. |
| Firedoor | Franklin Railway Supply Co., Inc., New York. |
| Grates | Waugh Equipment Co., New York. |
| Universal joints for valves, safety valves, gages, whistle, rail washer | Locomotive Equipment Division of Manning, Maxwell & Moore, Inc., Bridgeport, Conn. |
| Bell ringer | Superior Railway Products Corp., Pittsburgh, Pa. |
| Sanders | U. S. Metallic Packing Co., Philadelphia, Pa. |
| Headlight; generator; cab lamps | The Pyle-National Company, Chicago. |
| Piping | A. M. Byers Co., Pittsburgh, Pa. |
| Cylinder cocks; drifting valve | Ardco Manufacturing Company, North Bergen, N. J. |
| Cylinder and valve bushings; valves; valve bull rings and packing rings | Hunt-Spiller Manufacturing Corporation, Boston, Mass. |
| Whistle operating valve | Viloco Railway Equipment Co., Chicago. |
| Clear vision windows | The Prime Manufacturing Co., Milwaukee, Wis. |
| Smokebox hinge | The Okadee Company, Chicago. |
| Front-end tape | Union Asbestos & Rubber Co., Chicago. |
| Running boards | Alan Wood Steel Co., Conshohocken, Pa. |
| Flexible joints | Barco Manufacturing Co., Chicago. |
| Tender: | |
| Frame; truck | General Steel Castings Corp., Eddystone, Pa. |
| Tank steel | Bethlehem Steel Co., Bethlehem, Pa. |
| Tank valve | Everlasting Valve Co., Jersey City, N. J. |
| Tank hose | United States Rubber Co., New York. |
| Coupler | National Malleable and Steel Castings Co., Cleveland, Ohio. |
| Side bearings | A. Stucki Co., Pittsburgh, Pa. |
| Hand brake; draft gear | W. H. Miner, Inc., Chicago. |
| Clasp brakes; brake pins and bushings | American Steel Foundries, Chicago. |
| Brake shoes | American Brake Shoe Company, New York. |

# Future Freight-Car Trucks*

**By K. F. Nystrom†**

**Paper for Car Department Officers' Association year book sets forth requisites for satisfactory operation at speeds exceeding 85 m.p.h.**

THE war has caused some strange conditions with which car department officers and supervisors are confronted. We are loading cars heavier and operating trains faster with greater tonnage, thus causing more work and heavier repairs than in the past. Parts are failing which under ordinary conditions in the past gave satisfactory service. In addition, there is such a variety of special loads to be handled. As a whole, the car departments of American railroads, including Canada and Mexico, have functioned remarkably well and kept up a high standard of maintenance in spite of the severe shortage of manpower. The public and the government is showering us with praise which I am afraid will lull us into a state of complacency if we do not take time out to appraise the present and future situation and requirements. There is a great multitude of problems which will have to be solved as far as rolling stock is concerned if we are going to compete with other forms of transportation such as the private automobile, highway truck, buses and airplanes.

In my mind one of the outstanding problems which will have to be solved is an overall speeding up of freight movements. There are many cities on this continent which demand overnight and door-to-door service and it will be necessary to run freight trains in the future at a speed which only a few years ago was considered a fast passenger-car schedule. The stark facts are that we are not prepared at this time to run freight trains, say up to 100 miles per hour, as there is no suitable freight-car truck so far developed. The Milwaukee, during the past decade, has experimented with and tested more than a dozen different types of passenger- and freight-car trucks and, although we have been unable to solve the problem of producing a practical inexpensive lightweight and safe truck, we have determined some fundamental principles which must be satisfied in order to procure a freight-car truck as outlined above.

## Ride-Recording Instruments Essential

The first fact discovered from truck riding tests was that the human body can not judge riding conditions and least of all is it able to record the results. The human being is able to compare one car with another only if they are in the same train and then the impressions are of questionable value. We found that recording instruments are necessary so that the riding qualities of these trucks can be compared one with the other at a later date.

Car-body amplitudes of movement must be considered separately from accelerations or shocks, since, for example, a car body may have considerable vertical or lateral motion, but at a low frequency, and at the same time the accelerations may be quite low. By the same token, a car body or locomotive may be riding quite smoothly, but, at the same time, have shocks high enough that the instantaneous weight may be three to four times the normal value. The same facts hold true of the wheels, axles and other unsprung parts of the truck structure.

They may appear to be stable and have little if any vertical movement, but, at the same time, their instantaneous weights may be as high as seven times their normal values.

An observer can get the wrong impression of the riding qualities of two cars by watching a modern high-speed car being switched onto a train against an old-style low-spring-deflection car. The modern car, after the impact, will vibrate with a large amplitude sometimes as much as 1½ in., but at a low frequency, possible 50 cycles a minute, while the older car will have much smaller amplitudes but much higher frequency, in the neighborhood of 125 cycles a minute. The casual observer would predict that these two cars would operate at high speeds in this same relation, but the exact opposite is the fact.

The modern car will go through its harmonic frequency, that is the frequency of the blows from the rail joints will correspond with the natural frequency of the springs, below 20 m.p.h. while in the older car this will happen at a speed of about 50 m.p.h.

It is a fundamental fact that the highest acceleration and highest amplitude will prevail in the car body when the truck springs are in harmonics so one of the fundamental principles of the truck design is that the natural frequency of the springing system should be made as low as possible, while at the same time maintaining car body stability and keeping the coupler vertical travel within reasonable limits.

One of the greatest problems of high-speed freight-car truck design is to meet this one requirement because of the great difference between the weight of a loaded car and that of an empty car. Practical considerations set this vertical coupler travel at 2 in.; hence the load capacity of the car divided by maximum coupler travel allowed sets the spring rate of the truck springs. The natural frequency of any spring is determined by:

$$f = \frac{1}{2\pi}\sqrt{\frac{386}{defl.}}$$

in which $f$ equals the frequency in cycles per second; and *defl.* equals the deflection in inches.

It is evident that the lightweight of high-speed freight cars must be raised or the capacity must be lowered in order to get the harmonics of the spring system down to reasonable values.

---

* Paper submitted by request for inclusion in the 1943 Yearbook of the Car Department Officers' Association.

† Mechanical assistant to chief operating officer, C. M. St. P. & P., Milwaukee, Wis., and past president, Car Department Officers' Association.

## Ratio of Loaded to Light Car Weight Not Over Two

Our experience has shown that the ratio between the light car and loaded car must not be much over two if the car is to be operated at speeds as high as 100 miles an hour.

Another fundamental fact we have determined is that, with two trucks of identical design, the riding qualities will be a function of the spring rate, that is, the amount of load required to deflect the springs 1 in. The lower the spring rate, the better the car will ride. Of course, if this is carried too far, a state of extreme unstability at harmonics or resonance will be reached. Some method of auxiliary control must be used to carry the car safely through its resonance period, such as hydraulic shock absorbers, levelator bars, etc.

High-speed passenger cars have spring rates of such proportions that it is necessary to use these devices although the high spring rates that would be required in high-speed freight or express cars will not require any of these control devices.

We have also determined that the wheelbase of the truck has no function in either the vertical or lateral ride. We have tested four-wheel trucks with wheel bases varying from 5 ft. to 11 ft. at speeds as high as 105 m.p.h. and found no fundamental difference in their riding qualities, both vertical and lateral. There is, of course, some lower limit that you must not exceed on account of the tracking characteristics of the truck, but this lower value cannot be attained and get brakes, bolster springs and other equipment between the wheels. What this lower limit is we do not know, but we are certain that it is below 5 ft. 6 in. which seems to be the minimum wheelbase that can be attained.

With the same overall spring rates we have found that two spring systems, namely bolster and equalizer, will give a better ride than a single spring system. This seems to be due to the fact that one set of springs will dampen out the violent vibrations of the other while one is in harmonics. The spring systems, of course, are designed so that they will not both reach harmonics at the same speed. The spring deflection of one should not be more than one-half the spring deflection of the other. Of course, the fundamental drawback of two spring systems is that it increases the weight, cost, number of parts and also increases the wheel base of the truck.

We have further determined that lateral freedom other than that obtained in friction bearings should be used at speeds above 70 m.p.h. even on freight cars.

## Lateral Control Devices Not Yet Satisfactory

We have not yet been able to develop a satisfactory lateral device even for high-speed passenger cars. Swing hangers as they are now employed on high-speed cars leave a great deal to be desired. They can be designed to give a good lateral ride at certain speeds and certain track conditions, but as the speed changes from this value they allow the car body to swing as a pendulum, and also allow one car to influence another. We have assured ourselves that the distance from the center of gravity of the car to each truck should be the same, and of such value that the product of these distances should equal the radius of gyration squared. This value cannot be obtained on a freight car because it places the truck so far under the body that it could not negotiate heavy curvature track such as prevails on industrial sidings but it can be closely approximated on passenger cars.

We have found that it is important on passenger cars that the distance of the center of gravity from each truck should be the same even if their product cannot be made equal to the square of the radius of gyration. This condition is noticed in diners and rear-end cars where the distance of the center of gravity to each truck is not the same. It is a well-known fact that these cars do not ride as well as coaches, parlor cars and other well-balanced cars. The truck on the light end of these cars should be moved toward the center of gravity while the truck under the heavy end should be moved toward the end of the car or away from the center of gravity.

## Wheel Conditions Must Be Closely Controlled

It is an important requirement that wheels under high-speed equipment be kept concentric within .010 in. Their treads must be smooth and fairly close to the original taper. This does not mean that a wheel has to be the original 1 in 20 taper or that it cannot be run with considerable wear, but it does mean that the tread must not be allowed to develop local sharp tapers. The biggest factor in producing wheel shimmy is what the carman calls a second flange—a short sharp taper close to the throat of the main flange. Under high-speed equipment, this second flange can cause wheel shimmying if as high as $\frac{1}{16}$ in. We have had cars with decided wheel shimmy when the second shoulder could be discovered only by feeling, that is, it was not perceptible to the eye while the wheel was in the truck.

We have not been able to develop a truck design that will produce a suitable ride with wheels in this condition. The only way we have found to correct this condition is by returning the wheel to its original tread by turning or grinding. With any plans of high-speed operation there must be provision made for adequately maintaining the wheels in a high standard of perfection.

As the speed of freight or passenger trains goes up, the braking requirements increase rapidly, and any plans for high-speed operation, either freight or passenger, must include comprehensive braking improvements. Train-line pressures must be raised sharply because the brake propagation rate varies with the pressures carried.

## 85 M.P.H. Divides Low from High Speeds

The demarcation line between low- and high-speed train operation is 85 m.p.h. and not 60 m.p.h. as is the common belief. Many trucks that give a fairly good account of themselves at 80 m.p.h. and lower are entirely unsuited for speeds above 85 m.p.h. We have tested trucks in which the shocks or accelerations doubled when the speed was increased from 80 to 90 m.p.h. The amplitudes at 80 m.p.h. were entirely satisfactory but as the speed increased to 90 m.p.h. the car body became unstable and dangerous to operate. In the development of high-speed trucks, the tests must be run at speeds above their estimated operating level.

Sneaking box cars in an ordinary passenger train and hoping that they get to their destination does not constitute high-speed truck development. These trains rarely attain speeds above 75 m.p.h., consequently do not pass through the critical speed. After the box car has made several such trips, and has not wrecked the train, the natural thing is to assume that you have a successful high-speed truck because it has survived two or three trips in a passenger train. The cars on these trips are not under observation and nobody knows how close to disaster they may have been several times. Any truck developed in this way is an insecure foundation upon which to build high-speed operations.

### Four-Wheel Truck Generally Preferable

We have proved that, with equal spring rates and maintenance, a six-wheel truck will give a slightly better ride both vertically and laterally than a four-wheel truck, but the gain in riding qualities is far overshadowed by the increased weight, first cost, and maintenance cost. The braking qualities on a six-wheel truck have also been found to be slightly better than on a four-wheel truck.

A high-speed truck must be so designed that it does not lose its good riding qualities when the parts become slightly worn. Little is accomplished in designing and building a good-riding truck if it loses all these superior qualities with a little wear, which develops rapidly in any high-speed piece of equipment. Adjustments for wear and other operating conditions must be made as simple as possible so the yard forces can keep the truck at a high standard of maintenance.

In passenger trucks we found that the overall riding qualities would be better if we sacrificed some of the supersensitiveness of the truck when new. We eliminated all of the friction and sliding surfaces at some slight sacrifice of riding qualities when new in order to hold the truck to as nearly as possible a constant good-riding condition.

In passenger-car trucks, we changed from elliptic to coil bolster springs so we could more nearly keep a constant riding condition. The elliptic bolster springs, when new and well oiled and graphited will give as good a ride as the coil springs provided they have the same spring deflection. Some friction or damping is of value to control the spring system through its harmonic period, but too much is harmful especially at high speeds.

Elliptic springs soon develop friction due to corrosion far beyond damping requirements, and this excessive friction over minimum damping requirements detracts from the excellent riding properties of the truck. The coil springs remain constant in this respect over their entire life.

The introducing of coil bolster springs entirely changes the duty and purpose of the swing hangers. With an elliptic spring truck, the lateral motion is provided by the swing hangers and the slight motion that the elliptic springs allow between the spring plank and the bolster tends to damp out the pendulum motion of the swing hangers. In trucks equipped with coil bolster springs, the coil springs perform the same duty as the swing hangers in the elliptic-spring truck so the only duty left for the swing hangers to perform is a slight counter swinging to dampen out harmonic latitudinal motion of the large bolster coil spring.

We still use the same swing hangers on coil-bolster-spring trucks as on elliptic-spring trucks simply because we have not had time to develop a set of swing hangers that will function harmoniously with coil type bolster springs.

Frequent references have been made to development and experience we have attained in connection with passenger trucks. These were made for only one purpose, namely, to try to unfold the problems and difficulties surrounding the development of a safe, practical, light-weight and inexpensive high-speed freight-car truck. Positive statements have been made as to conclusions reached. From experience, we know positively that if new conditions are set up, the fundamentals found under one condition may change entirely and new bases have to be provided. It is hoped that this discussion will be a challenge to designers and car men to develop a satisfactory high-speed freight car truck.

## Lehigh Valley Locomotives

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truck, equipped with Franklin C2a booster, was furnished by the same manufacturer and has a swing of 8¼ in. each side of the center line.

The main wheels of these locomotives are cross balanced. The total weight of reciprocating parts on one side is 1,932 lb., 33.6 per cent of which is balanced. The overbalance at front, main, intermediate and back wheels is 175, 150, 154 and 171 lb. respectively. The dynamic augment at diametral speed varies from 7,725 for the main wheel to 9,000 lb. at the front wheel.

The 12-in piston valves are actuated by Baker valve gear controlled by an Alco Type G power reverse gear.

Mechanical lubrication is accomplished by the use of two Detroit Model B 32-pint, 16-feed lubricators both located on the right side and driven from the motion work. One lubricator serves the wedges, pedestal faces, valve crossheads, truck pedestals and center plates, reverse gear, trailer truck and radial buffer. The other lubricator serves the stoker engine and shaft bearing, driver hub faces, booster, headlight generator, feedwater pump, guides, cylinders and valves. Pressure grease fittings are used in numerous locations on the running gear, spring rigging, motion work and throttle rigging.

The operating brake equipment is the Westinghouse Schedule 8 ET designed with braking power equivalent to 60 per cent of the weight on drivers at 50-lb. cylinder pressure. The foundation brake was supplied by the American Brake Division of that company and is the Schedule N275-114.

The cab is the conventional steel riveted construction with shatterproof glass in the windows. The cab is larger than that of the original T2 class with provision for the trainman's seat.

The tenders of these locomotives have completely welded tanks having capacity for 20,000 gals. of water and 30 tons of coal. The tank is mounted on a General Steel Casting Corporation's water bottom tender frame. The entire structure is supported on two six-wheel equalized trucks, supplied by the same manufacturer. The trucks are equipped with roller bearings and clasp brakes. The tender draft gear is the Miner A-22-XB.

**How to Get More Efficient**

# Locomotive Performance*

**By Theo. Olson†**

**Fit motive power to railway needs instead of the reverse—Tighten up on operating practices and help supervisors to exercise intelligent leadership**

THE steam locomotive is still used to handle most of the tonnage on American railroads. Therefore the efficiency of this type of power unit necessarily has a decided influence on the performance and success of railroad operation generally. Statistics indicate that during the year 1943, of all locomotive miles made in freight service, 97.1 per cent were made by steam locomotives and the balance, 2.9 per cent, by locomotives other than steam. Of all the motive power miles made in passenger service, 70.1 per cent were made by steam locomotives and 29.9 per cent by locomotives other than steam including motor cars. In yard service 81.8 per cent of the miles made were by steam locomotives and 18.2 per cent by locomotives other than steam. For the year 1941, the latest figures available on the subject, $335,104,820 was spent in the maintenance of steam locomotives. For the same period $302,488,277 was spent for fuel for these steam locomotives. In view of the large amount of money involved, there is necessarily a great field for economy.

Steam locomotives may be considered to have a high degree of efficiency when they: (1) Handle trains on schedule time; (2) perform uniformly throughout their service periods without delays on the line or failures, thus assuring dependability and eliminating the necessity of maintaining extra units for relief purposes; (3) require minimum attention at terminal points between shopping periods, thus affording maximum availability; (4) produce good fuel records; and (5) are economical to maintain.

In order to obtain the best results in railroad operation, it is necessary that the motive power be fitted to the needs of the railroad rather than trying to provide service based on the design of the motive power, whether or not it is adapted to the requirements of the service on the property. If high-speed service is required, it would be absurd, to say the least, to believe that efficiency in locomotive operation could be obtained with power units designed primarily for slow speed. On the other hand, if speed combined with heavy tonnage is required, a high degree of efficiency would not be obtained unless the motive power available were commensurate with the requirements. Therefore, it goes without saying that the primary and all-important consideration is that of selecting the right resign of motive power for each particular territory, depending on such conditions as (1) speed required and (2) tonnage available, which together with the frequency of service requirement will determine the practical tractive effort requirements of the power unit. Assuming that an opportunity is afforded for selection of the proper motive power for the service requirements, the foundation is laid for efficient locomotive performance.

## Increasing Locomotive Utilization

The next step is to determine the most practical utilization of the locomotives by making locomotive runs as extended as possible so as to obtain high mileage per unit. Lay-over periods at outlying points where I. C. C. inspections and heavy repairs are not handled should be shortened as much as possible. In order to operate locomotives successfully over more than one district without any attention other than main-line servicing at terminal points, locomotives must be designed to steam freely; the grate designs must be such as to minimize cleaning of fires where coal is used for fuel; and boilers and fireboxes must be maintained in first-class condition to eliminate firebox leaks enroute. Proper feedwater conditions are also necessary so as to eliminate boiler foaming tendencies.

Having extended locomotive runs to give the highest obtainable mileage, the next objective is to minimize the time locomotives are held out of service for repairs. Invariably it is possible to handle whatever machinery repairs are required for a 30-day period at the monthly I. C. C. inspection and this practice is now being followed to a great extent by many railroads. The length of time that locomotives may be out of service for the monthly, quarterly and semi-annual inspections, together with whatever machinery repairs are necessary to keep locomotives serviceable for the next 30-day period, will depend on the enginehouse facilities available.

## Modern Terminal Facilities Needed

With the investment involved in modern motive power, it pays to provide enginehouse facilities at central repair points with modern equipment so that, ordinarily, repairs required to cover a 30-day period can be completed within a 24-hour period. The question of whether or not boiler washing is necessary between the 30-day inspection period is largely dependent on water conditions and the best solution arrived at in each particular territory. Where water contains a considerable amount of solids, it may not be practical to attempt to run locomotives 30 days between washout periods.

The mileage between classified repairs is dependent on so many variables that it can be arrived at only through actual observations of the locomotives under established service conditions. Whenever possible, the classified repairs should be matched up with the major inspections such as annual and cap inspection, flue renewals and the removal of the jacket and lagging. In all cases, these major inspections should be handled during the classified

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* Paper prepared for the 1943 Year Book of the Railway Fuel and Traveling Engineers' Association.

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repair period so that the locomotive will not need to be tied up for such inspection for 12 months following classified repairs, unless classified repairs would again be contemplated earlier.

Proper planning of classified repairs to locomotives will assist greatly in minimizing the out-of-service period and thus increasing the over-all availability. If for any reason it becomes apparent that certain units must be shopped ahead of the pre-determined shopping schedule, it is advisable to provide sufficient flexibility in schedules to permit handling the more important power units promptly without delay in preference to those of less importance. Material needed in connection with classified repair of locomotives should be kept on hand and certain material prepared in advance so that the shopping period will be reduced to a minimum and should be as nearly as possible limited to not more than two weeks.

### Competent and Tactful Supervision Essential

Assuming that the desired train loads are handled on scheduled time, peak availability and high mileage per unit secured, and maintenance and operating practices properly coordinated, the result will be efficient locomotive operation. This result, when produced, must be credited, to a great extent, to systematic and intelligent locomotive maintenance and operating supervision. As we know, there are any number of slight oversights, slipshod workmanship, small acts of carelessness here and there that can easily upset the entire program and cause not only delays enroute but failures and breakdowns, irrespective of the fact that the power units are basically sound and would perform up to expectations if proper attention were afforded all details.

Irregularities causing delays on the line whether from some oversight by the maintenance forces, or lack of judgment and experience by the engine crews in charge (for which there is no basic reason other than human errors) can best be eradicated by proper and efficient training of the employees involved. Supervisory forces in the maintenance department, as well as road foremen and other mechanical supervisors on the line, must not fail to contact the employees under their supervision frequently and discuss with them in an instructive manner the proper performance of their duties as well as indicate the results from improper or careless work. It is a task that is never fully completed, but pays good returns.

The method used in conveying educational instructions to employees need not be uniform. No formula could be be devised that would fit and be acceptable in all cases. The primary objective is after all to obtain results and if possible in a manner that will be least objectionable to the employees. Most employees will take pride in the work they are performing, particularly if they are brought to a realization of the importance of their respective duties and the part that they are playing in the general success of the railroad by which they are employed.

Frequent, intelligent, educational instructions to employees maintaining and operating locomotives, by supervisors in charge is just as essential for efficient locomotive performance as the periodical inspection and servicing of the locomotives involved. It is too late to talk about what could have been prevented after it has happened and therefore experienced supervisors, who have by natural adaptability or training become masters in their vocation, will invariably carry on educational conversations with the employees for the purpose of preventing trouble. This is in a measure as important as rigid inspection of locomotives to prevent breakdowns.

### Economy Can Be Carried Too Far

The nature of the work performed by steam locomotives is invariably such that it is more important to obtain maximum efficiency than it would be to practice certain economies if this would to any degree minimize the output or lower the performance of the power unit. Usually, efficiency is of prime importance and economy can be practiced only to the extent that it will not interfere with the peak performance of the locomotive. While it may be possible to reduce the maintenance cost as well as cost of certain supplies, if such economy would to any extent reduce the serviceability of the locomotive to the transportation department, the small amount saved may result in increased transportation costs many times greater.

Therefore, it is a good rule to follow that any economy which would interfere with maximum efficiency and dependability of the locomotive should not be considered. To illustrate the point, there may be conditions arising which will create inducements for permitting locomotives to remain in service after reaching a mileage that warrants shopping and it may appear economical to get additional mileage, yet, if a failure occurs with the locomotive while in a shopworn condition, the contemplated savings by obtaining some extra miles is lost and usually added expense incurred. In the use of lubricants on friction bearing locomotives, it may appear that driving-box grease cakes will make another trip without replacement, but, if a delay occurs on account of trying to get the last mile out of the driving-box grease cakes, the expense incidental to such delay will amount to more than many new cakes of driving-box grease.

If, on the run, a ton of coal is saved on ascending grades by favoring the locomotive and a poor run is made as a result thereof and important connections missed, the amount of fuel saved was paid for dearly in other ways.

Low lubrication cost per mile is desirable, but, if the service life of cylinder packing or valve rings or any of the reciprocating or rotating bearings can be increased and frictional resistance reduced by more liberal use of lubricants, it is sound economy to increase lubrication to a point where it is ample but not wasteful, irrespective of increased cost per mile.

### Motive Power Changes of General Benefit

When considering economy in locomotive operation, it is imperative that all angles be considered from a broad long-range viewpoint. The effects of any contemplated changes in locomotive design, material specification, appurtenances, maintenance or operating methods should not be referred to as economy until their worth has been proved from an unprejudiced viewpoint that takes into account the general benefit of the railroad as a whole.

There are in the field of locomotive operation a great number of consistent economies that should be practiced whenever possible. With reference to locomotive maintenance, it is sound economy particularly with reference to motive power that is used in fast and heavy service to eliminate the piecemeal method of making repairs by setting up only a reasonable mileage between classified repairs. The improved results by elimination of failures and intermittent tie-ups for repairs produce both economy and generally more satisfactory service.

A high standard of boiler maintenance, together with a well-supervised boiler feedwater program, is good sound economy. Leaky flues and fireboxes, hard-steaming loco-

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**Henderson Medal**

# Award to Joseph B. Ennis

## Franklin Institute honors him for his many contributions to development of the locomotive

"IN consideration of his accomplishments in locomotive engineering and important contributions in the field of locomotive design." Thus read the citation for the George R. Henderson Medal which was awarded by the Franklin Institute of Philadelphia to Joseph B. Ennis, senior vice-president of the American Locomotive Company, on its Annual Medal Day, April 19.

For almost half a century, which covers Mr. Ennis' active business career, he has been engaged in the designing of locomotives. It is interesting to recall that after George R. Henderson retired from active railroad service in 1903 and established an office as a consulting engineer in New York, he came into intimate contact with Mr. Ennis, who at that time was in charge of designs, calculations and specifications at the headquarters office of the American Locomotive Company in New York City. Undoubtedly he was indebted to Mr. Ennis for considerable data which were incorporated in Mr. Henderson's two books, Locomotive Operation (1904) and Cost of Locomotive Operation (1906), which were highly regarded and had a strong influence during the early part of the century in establishing a trend toward making a better and more scientific use of the locomotive.

Joseph B. Ennis

The records also indicate that during the same year in which Mr. Ennis entered the service of the Rogers Locomotive Works (1895) Francis J. Cole became mechanical engineer of that company. For many years thereafter these two men were closely associated. In a way they had much in common, for they were both capable, quiet and unassuming. George M. Basford, at that time editor of this publication (then known as the American Engineer and Railroad Journal) did succeed in getting Mr. Cole to write a series of articles on locomotive design and proportions, which extended over a period of four years, beginning in 1898. They proved to be an important factor at that time in making our publication indispensable to railway mechanical engineers and mechanical department officers, and in stimulating a keen interest in the development of more scientific locomotive design, both as to details and better balanced proportions. It is little to be wondered at, therefore, that Mr. Ennis, profiting by these associations and experiences, should have gone steadily forward, until today he is so highly honored for the work that he has done in the field of improved locomotive design and utilization.

While he has shunned personal publicity and has preferred to remain more or less in the background, his individual contributions to the design of specific locomotives built for many railroads have been recognized and greatly appreciated by railway mechanical department officers.

There are a few instances, however, in which Mr. Ennis was obviously given free rein and which have resulted in epoch-making designs. Typical of these—and it is interesting to recall it at this tenth anniversary of the introduction of streamlined trains—is the high-speed steam 4-4-2 locomotive, the Hiawatha, of the Chicago, Milwaukee, St. Paul & Pacific, which captured the imagination of the American people at a time when the other streamlined trains were powered by internal combustion engines.

During the early part of the century tractive force was the measure of locomotive capacity and heavy drag, slow-speed service was the standard practice for freight operation. With the transition in operating conditions the trend to increased gross-ton-miles per train-hour evidenced itself and there was a pressing demand for locomotives of a totally different design, wherein horsepower and not tractive force was the measure of capacity.

The issue was squarely faced in 1912, when the American Locomotive Company designed and built its famous experimental Pacific type locomotive, known as No. 50,000. Mr. Ennis, who was then mechanical engineer of the American Locomotive Company, did the preliminary work in developing it, and the ultimate success of this experimental locomotive and the designs which followed its general pattern, are said to be due largely to Mr. Ennis' engineering skill.

Another unique example of a locomotive designed under Mr. Ennis' direction was the so-called Timken locomotive. While the objective was primarily to demonstrate the feasibility of the application of roller bearings to all the axle journals of a steam locomotive, it was modernized also in all other respects. Fifty-two other

specialty manufacturers cooperated with Timken and the American Locomotive Company, with the understanding that the locomotive would be available for demonstration purposes on a number of railroads over a two-year period. It was eventually sold to the Northern Pacific.

Mr. Ennis has always sought to encourage the development of locomotive specialties which might increase the capacity and efficiency of the locomotive. He has been unusually successful in co-ordinating into well-balanced designs such improvements as superheaters, stokers, feedwater heaters, roller bearings, mechanical lubricators, cast-steel integral structures, flexible staybolts, power reverse gears, alloy steels, welded construction and other devices.

While Mr. Ennis' name was not identified in current literature with the development of the Mallet locomotive in this country, it is no secret that he co-ordinated into workable designs the ideas and suggestions of those whose names were more prominently associated with the various designs built by his company.

He was an important factor in supervising the design of the twelve standard types of locomotives for the Railroad Administration during the first World War. At the time of the federal valuation of the railroads the Interstate Commerce Commission requested certain confidential information from the American Locomotive Company. Mr. Ennis supervised and directed the collection of a tremendous amount of data, which formed the nucleus of the Commission's report on the general valuation program. Later, when individual railroads experienced difficulty in estimating the cost of reproduction of their equipment, the President's Conference Committee, through a sub-committee, called upon Mr. Ennis and his organization to furnish the cost of reproduction of locomotives. This cooperation lasted more than ten years.

While Mr. Ennis is regarded as one of the foremost authorities in the field of steam locomotive design, he has taken a keen interest in electric locomotive development, and was also one of the first to recognize that the Diesel locomotive would play an important part in transportation development in the future. From 1920 to 1925 he maintained an assistant in Europe to investigate and follow Diesel development. In 1926 he had this to say in his annual report to the president of his company: "Granting that it will be a long time before the oil locomotive will be a real competitor of the steam locomotive, there is no doubt of the interest of railroad men in this locomotive, and from the results already obtained, especially as regards fuel savings and continuous service, I believe there will be a steady demand for these locomotives, increasing as we are able to furnish larger units." Diesel-electric switching locomotives were introduced by his company in 1924.

Joseph Burroughs Ennis was born in Wortendyke, N. J., May 20, 1879. His father was general foreman of the New York, Susquehanna & Western shop at that point. On graduating from high school in 1895, he went to work in the drawing office of the Rogers Locomotive Works at Paterson, N. J., advancing from tracer to detail draftsman, and then to elevation draftsman. In 1899 the Rogers Works was temporarily closed and Mr. Ennis went to the Schenectady Locomotive Works as an elevation draftsman. He returned about a year later to the Rogers Locomotive Works, but in 1901 became an elevation draftsman at the Cooke Works of the American Locomotive Company. In 1902 the office of the chief mechanical engineer of the American Locomotive Company was moved to New York and Mr. Ennis was transferred to that place and put in charge of designs, calculations and specifications for locomotives. In 1906 he was appointed assistant to the mechanical engineer; in 1908 designing engineer; in 1912 chief mechanical engineer; in 1917 vice-president in charge of engineering; in 1924 he was made a director of the company; and on January 1, 1941, became its senior vice-president.

## More Efficient Locomotive Performance

(*Continued from page 208*)

motives and boiler foaming tendencies will prevent proper performance of the best locomotive ever designed. Under conditions where blowing of boilers on the line is necessary to maintain good boiler conditions, the continuous automatic blow-off system has proved of great value.

Close and careful attention to valve setting and the most painstaking care in eliminating any defective condition about the valves, cylinders and valve-gear parts is consistent, and, while considerable labor cost may be involved in inspection only, it is warranted as it will prevent many annoying delays and produce economy much greater than the maintenance cost involved. Periodical inspection of cylinder packing and valve rings is now generally adopted and has proved to be money well spent.

### Great Savings Possible by Fuel Economy

In the furtherance of economy in locomotive operation, undoubtedly the greatest opportunity is in the use of fuel. Ordinarily, when fuel is used in a wasteful manner, it is accompanied by additional penalties besides the cost of the extra amount of fuel burned. If improper firing methods are employed resulting in loss of fuel, invariably they are accompanied by certain abuses of the firebox sheets and flues such as by uneven firebox temperature due to the fire being light in one place and too heavy in another part of the firebox. Poor fire conditions may cause injudicious shaking of grates, resulting in a tendency to stop up flues and thus impair the efficiency of the locomotive still further. Wasteful firing methods are usually accompanied by improper boiler feeding with its detrimental effects on the boiler and firebox sheets. Generally when locomotive fuel is being handled wastefully, other incorrect practices follow and the effects of fuel waste are more far reaching than the actual cost of the extra fuel consumed.

One important factor in locomotive operation is cooperation between the maintenance forces and the enginemen operating the locomotives. Many unnecessary and expensive testing operations can be eliminated by enginemen making intelligent and authentic reports of the conditions of the locomotives on arrival at terminals. Likewise many annoying delays can be avoided by maintenance forces advising enginemen regarding any part of the locomotive that should be given particular attention during the trip such as new bearings of various kinds being applied which may require special care. Locomotives should be made as comfortable as possible and appurtenances with which locomotives are equipped maintained to function without inconvenience. If enginemen are fully satisfied with locomotives, better performance is usually obtained.

Irrespective of the outstanding performances that have recently been accomplished by steam locomotives on U. S. railroads, there are still ample opportunities for further progress and economy which should stimulate efforts to greater achievements in the future and a keener realization by railway men of their responsibilities in this important phase of railroad operation.

# Diesel Locomotive Ratings*

By B. S. Cain†

**Effective application of this type of motive power requires understanding of electric transmission and engine as well as locomotive characteristics**

THE Diesel-electric locomotive can be rated in various ways, because each piece of power equipment has its own rating individually or may be rated collectively with the other equipment on the locomotive.

The locomotive rating may be expressed in pounds force exerted or in horsepower; in some cases kilowatts produced as well as in B.t.u. consumed.

The drawbar-pull ratings of a Diesel locomotive may be obtained by the use of a dynamometer car. If a true comparison is to be made between a steam and Diesel locomotive, it can best be made by the use of a dynamometer car, using the same car and crew to perform both tests. The locomotives should be tested so that their full capacity ratings at the drawbar will be obtained at all locomotive speeds.

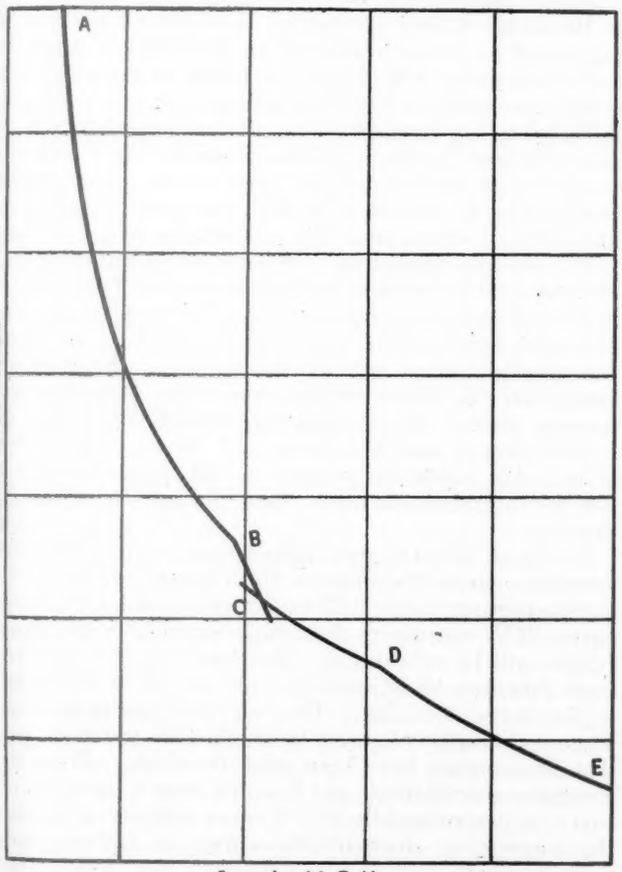



Fig. 1—Typical Diesel-electric locomotive tractive-force-speed curve

The tractive-force rating consists of the drawbar-pull rating plus the locomotive journal and air friction. It can be obtained from the drawbar-pull data by calculation, using the Davis friction curves. The tractive-force rating in starting depends upon the weight on drivers, regardless of available horsepower. This was frequently taken as 30 per cent for Diesels and 20 to 25 per cent for steam. In recent years, 25 per cent has been generally adopted for both steam and Diesel.

The tractive force may be calculated directly and with greater accuracy from the generator and motor characteristics obtained from shop test.

Fig. 1 shows a typical locomotive characteristic curve. The portions *AB* and *CD* represent substantially full utilization of engine horsepower. The parts *BC* and *DE* show some reduction in horsepower because the generator voltage has reached its limit (section *AB* in Fig. 2). At *C* there is a change in the connections of the motors, from *A* to *C* motors are in series and from *C* to *E* they are in parallel.

## Traction-Motor Rating

The characteristics of the direct-current, series-wound traction motor are such that at low speeds high tractive force, corresponding to high current, is obtainable with relatively low voltage at the motor terminals. High speeds with decreased tractive force require increased voltages and lower currents. The increase of voltage with decrease of current is also necessary to utilize the full power of the Diesel engine.

The power which the locomotive can deliver is limited in two different and distinct ways: First, the Diesel-engine output is limited, regardless of the speed and tractive force of the locomotive. Second, the length of time during which the electric transmission can deliver power is limited, over part of the range, by heating of the equipment. The most important factor in electric transmission heating is generally the current in the motor and generator windings. Voltage and speed also have an important influence. The effect of heating is not immediate. Insulation gradually deteriorates with time and the higher the temperature, the faster the deterioration. It is, therefore, usual to establish a normal temperature limit for electrical equipment and also a peak value which may be reached occasionally without excessive deterioration of insulation. If peak temperatures are high enough to melt solder, damage to the equipment may be rapid and serious.

The principles governing heating of electrical equipment are explained in detail in Standards of the American Institute of Electrical Engineers.‡

It will be seen that Diesel-electric locomotives must

* Abstract of a paper submitted by title before the Railroad Division at the annual meeting of the American Society of Mechanical Engineers at New York, December 2, 1943.

† Assistant engineer, locomotive engineering division, General Electric Company, Erie, Pa.

‡ See "Introduction to A. I. E. E. Standards: General Principles upon which temperature limits are based in the Rating of Electric Machinery and Apparatus. A. I. E. E. No. 1"; also American Tentative Standards for Railway Motors and Other Rotating Electrical Machinery on Rail Cars and Locomotives. A. I. E. E. No. 11."

be used according to instructions and within limits specified. Too high a tractive force for too long a time will result in overheating and deterioration or damage. One object of rating the equipment is to determine in what classes of service the locomotive can safely be used.

Traction motors, tested under A. I. E. E. Standard No. 11, may have three classes of rating: (a) continuous, (b) one-hour, and (c) thermal capacity. It is usually unnecessary to determine both the continuous and one-hour ratings, the former being almost universally used particularly for ventilated motors, and the latter chiefly useful for totally enclosed motors. In brief, the continuous capacity is the shaft horsepower output that can be carried for an unlimited period on stand test at rated voltage without exceeding specified limits of temperature rise; for example, 120 deg. C. measured by resistance of armature windings. The one-hour rating is the shaft horsepower output which can be carried for one hour on stand test, starting at room temperature, without exceeding the specified limits of temperature rise. The thermal capacity rating is the average time in seconds

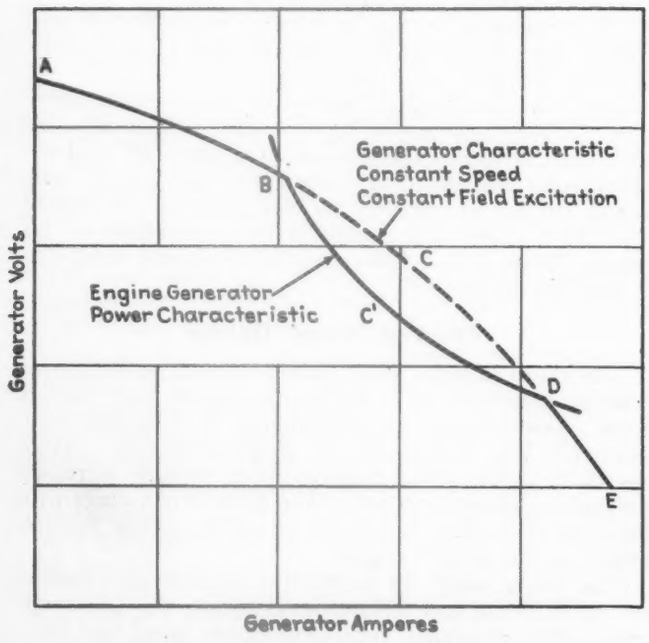



Fig. 2—Diesel-electric generator characteristic

per deg. C. for the motor to rise in temperature approximately 60 deg. C. (100 deg. C. to 160 deg. C.) to the peak allowable temperature with a current of 1.6 times its continuous rated current.

Traction-motor characteristic curves show tractive force, speed and efficiency plotted against current. These curves are at full rated voltage. It is not necessary that the traction motors should have the same power rating as the Diesel engine. The Diesel engine power represents the maximum which the locomotive can produce, while the necessary traction motor power rating more nearly reflects the motor heating. It is very important that the motor heating should not be excessive due to too great a tractive force for too great a time.

A measure of motor heating in service can be obtained from road tests carefully performed and analyzed, or it can be estimated approximately from elaborate stand tests on motor heating and cooling curves, which can very seldom be justified.

The usual measure of motor heating is based on the continuous (or one-hour) rating and on the short-time thermal capacity rating. It is often convenient to express these in terms of per cent locomotive adhesion. Thus if the continuous motor rating corresponds to a total tractive force equal to 12 per cent of the static weight on drivers, the locomotive would be said to have its continuous rating at 12 per cent adhesion. Similarly, if the thermal capacity rating corresponds to a total tractive force equal to 20 per cent of the static weight on drivers, the thermal capacity, in seconds per degree, gives a rough measure of the time for which the locomotive can exert this high tractive force without exceeding the allowable peak motor temperatures.

## The Engine-Generator Set

The traction generators, tested under A. I. E. E. Standard No. 11, may have two classes of ratings: (a) continuous, and (b) thermal capacity. These are similar to the motor ratings except that the continuous rating is expressed as power delivered at any voltage from the maximum to the voltage corresponding to the maximum continuous rating. For thermal capacity, the generator is loaded to full rated power at 50 per cent of rated voltage (the rated voltage is the maximum at which the generator can absorb the full input of the Diesel engine continuously). It will be evident that generator heating may limit a locomotive in the same way as motor heating.

The electric transmission, in its simplest form, consists of a generator coupled to the Diesel engine, driving a motor coupled to a locomotive axle. By changing the generator field exciting current, the generator can produce a wide range of voltages and currents and can, therefore, drive the motor over a wide range of speeds and tractive forces. In practical applications, there may be several motors and generators and the exciting current is limited by automatic control, so that the generator will not try to take more power than the Diesel engine can produce.

In Fig. 2, *ABCDE* represents the curve of volts against generator current in amperes for a constant speed and a constant setting of the field excitation control. The lower curve *BC'D* represents the limit above which the Diesel engine will be overloaded. The load regulation control must therefore be adjusted to hold as nearly as possible to the curve *ABC'DE*. The calculated generator volt-ampere characteristic must be checked by test to be sure that adjustments have been properly made. From this generator characteristic and from the motor characteristic curve, as determined by test, it is not difficult to calculate the locomotive characteristic curve of tractive force against speed.

The testing of a Diesel engine in the shop is in the nature of a preliminary check on the engine alone. Actually, the final testing generally occurs after the engine has been assembled with the generator and placed on the locomotive. The object of that test is to obtain a predetermined generator curve similar to *ABC'DE* of Fig. 2, which actually determines the output of the locomotive at the wheels. The engine must have power not only to meet this curve, but handle all auxiliaries and have at least a slight surplus. Furthermore, this output may be on a continuous basis or a short-time basis, depending upon the service the locomotive is in. Therefore, the service must be analyzed before the final loading on the engine can be determined.

## Matching the Locomotive with the Service

There are two methods of determining the service for which a Diesel-electric locomotive is suited. The first is by means of road tests and the second by calculation. The

road tests are made by putting the locomotive in the service in question, carefully recording the speeds, train weights, etc., and measuring the temperatures of the equipment. This indicates directly whether the locomotive is loaded correctly up to its limit. If it is not, the necessary change in loads can be estimated and, if necessary, checked by further tests. This method is simple in principle, but may be difficult and expensive to carry out in practice. It gives a result only for the particular service tested and it cannot, of course, be used before the locomotive is built. The method of road testing is, therefore, usually confined to checking calculations in cases where enough locomotives are involved to justify the time and expense.

The method of calculation may be carried out with varying degrees of refinement. The first step is to select train weights, and calculate the speed-time-distance current curves for the services involved. The square root of the mean square of the current (r.m.s. current) is a rough measure of heating and may be compared with the continuous rated current of the transmission. The peak temperatures which will be reached may be roughly estimated from the peak currents and the thermal capacity rating.

For heavy service the Diesel engine has a continuous power rating, which it should be able to deliver without smoke, undue heating, or excessive maintenance. The engine cooling system should be able to maintain water and lubricating oil temperatures within specified limits on a similar continuous basis.

At the other extreme, for light service, which is represented by much industrial switching, the Diesel engine may have an intermittent power rating which means that it can operate on a cycle of 30 minutes at full load, full speed followed by 30 minutes at 50 per cent load, repeated a number of times without undue heating or smoke. Engines restricted to light service, however, must operate with a service load factor of not more than 50 per cent if they are to give reasonable service.

It should be emphasized that the load factor alone does not determine the service; for example, if a switching and transfer locomotive operates on 16 per cent average load factor, but has an occasional heavy drag of full load for about 60 minutes, it would require a heavy service rating, since the time at full load would be limiting.

Having once determined whether the engine is to be on a short time or continuous basis, final tests can be made. The ratings of each of the auxiliaries must be determined. These include the radiator fans, traction-motor blowers and ducts to the motors, air-brake compressor and auxiliary generator with its various loads. These auxiliary-generator loads include power to charge the battery, for fuel transfer pump, control circuits, lighting, excitation, electrical boiler circuits if any, and other miscellaneous auxiliaries such as windshield wipers, etc. The power to operate these all come from the engine and must all be accounted for. It usually amounts to between four and 10 per cent of the total.

Adding all these auxiliaries to the power delivered to the main generator gives us the gross output of the engine. Even though the output to the main generator is continuous, as outlined, because of service conditions the auxiliary load will not necessarily be continuous, which means that the gross output may vary as much as 7 per cent.

Therefore, with all these variable percentages added up, we find the actual engine output may differ considerably from the factory rating which is generally quoted in round numbers to indicate the approximate engine output, either gross or for traction.

## The Diesel Engine

The output of a Diesel engine varies with many external conditions. Engines are often rated at 60 deg. F. and 29.92 in. Hg. pressure, but for some classes of locomotives the basic rating has been considered to be at 90 deg. F. and 27.8 in. Hg. pressure, in order to cover a greater range of conditions. Greater unification of practice is desirable.

The indicated engine horsepower is seldom referred to, but of course is there and must be considered by the

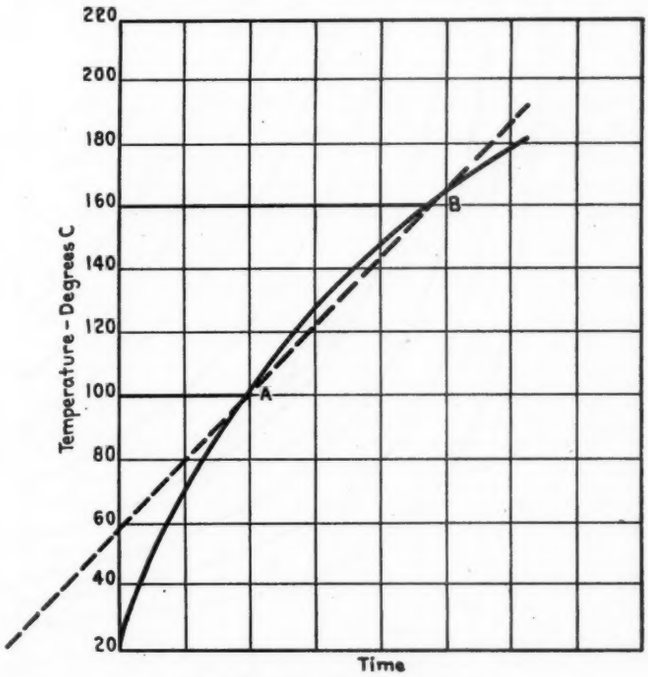



Fig. 3—Traction-motor heating curve

builder. The indicated horsepower of the steam locomotive is one of the few means of determining the rating of a steam locomotive so it has to be used. However, as there are so many places on the Diesel locomotive to obtain ratings, it is preferable to use one of the more tangible ratings and one nearer to the drawbar.

## Thermal Rating

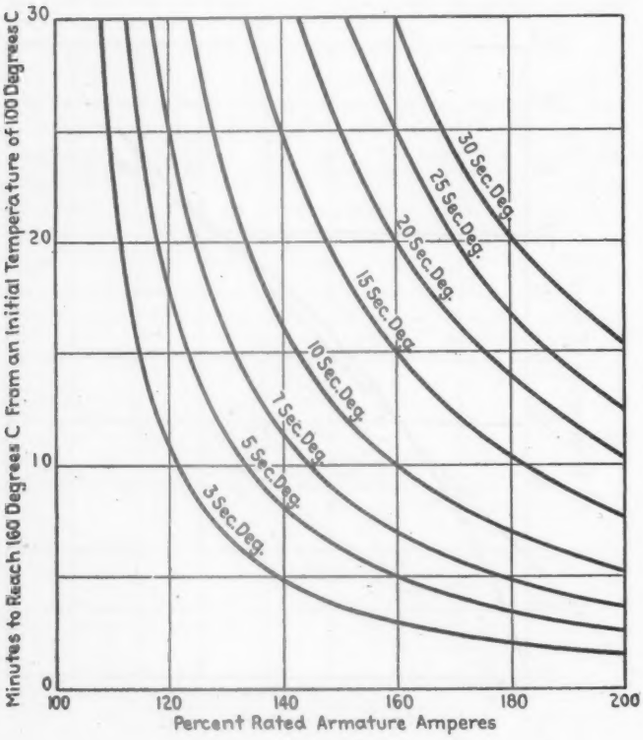
Thermal input may also be considered a locomotive rating. We normally refer to a locomotive having a consumption of so many gallons of fuel oil per hour. We should, however, refer to so many B.t.u. burned per hour with the proper correction factors used. From this rating we obtain the thermal efficiency. When determining such a locomotive rating of B.t.u. per hour, consideration must be given as to how many auxiliaries are functioning and whether a train heating boiler is also included. Incidentally, the boiler rating is an important percentage of the thermal rating.

It is possible for a Diesel locomotive to be operating at a certain output and then take on board a new load of fuel oil having a higher or lower B.t.u. value. This additional fuel oil may change the locomotive output, not only due to its different B.t.u. value but also many other possible changes in the fuel including temperature, viscosity, sediment and ignition quality.

## Thermal Capacity as a Rating Tool

The thermal capacities of motors and generators are expressed in seconds per degree and represent the

average rates of heating between 100 deg. C. and 160 deg. C. under a particular overload current. In order to obtain a composite rating, it is necessary to be able to convert ratings from one current to another. Fig. 4 provides a series of curves which can be used for approximate conversions. Their use is best known by an example: Suppose we have a locomotive in which a traction generator rates full engine horsepower contin-




To use this chart two A. I. E. E. ratings are required: (1) No. 11—continuous armature rating in amperes, and (2) No. 11, Appendix No. 1—thermal capacity rating of the armature in seconds per degree (not limited by the armature in all cases). Use the curve corresponding to the thermal capacity rating of the armature.

**Fig. 4—Armature short-time heating curves for blown machines rated for 120 deg. C. by resistance**

uously from 750 volts and 940 amp. to 510 volts and 1,350 amp. The thermal capacity rating will be at half the maximum rated voltage; that is, at $750/2 = 375$ volts, at which the current is 1,800 amp. Suppose the thermal capacity rating is 30 sec. per deg. at this current. Now consider the traction motors, connected four in series across the generator. They have a continuous rating of 830 amp. per motor, so that the thermal capacity will be at 1.6 times $830 = 1{,}330$ amp. Here the generator will carry the motor overload continuously and it is clear that for short-time overloads the motors will be limited and not the generator. Suppose that the motor thermal capacity is 20 sec. per deg. and that we are interested in a short overload during which the locomotive exerts 25 per cent adhesion, which requires 1,500 amp. per motor. This is 181 per cent of continuous rated current and the curve in Fig. 4 which is labeled 20 sec. per deg. shows that at 181 per cent of rated amperes it takes 13.7 minutes to reach 160 deg. C., starting from 100 deg. C. This gives a direct indication of about how much overload the locomotive will stand, and may be expressed as a locomotive thermal capacity rating at 25 per cent adhesion of 13.7 sec. per deg.

Now let us suppose that the motors, instead of being in series, are connected in two parallel circuits, so that the generator must take twice as much current as any traction motor. At 25 per cent adhesion the generator would be required to take 3,000 amp., which would be far beyond its capacity. At 15 per cent adhesion the motor current would be 950 amp., while the generator current would be 1,900 amp. The motor current is 114.5 per cent of rating and Fig. 4 shows that the motor thermal capacity under these conditions would probably be over one hour. Now if the generator has a test thermal capacity rating of 15 sec. per deg. at 1,800 amp., which is 133 per cent of continuous rating, Fig. 4 shows a capacity of 11.5 sec. per deg. at 141 per cent of continuous rating (1,900 amp.). In this case, the generator would be limiting and the thermal-capacity rating of the locomotive at 15 per cent adhesion and with motors in parallel would be 11.5 sec. per deg. It will be evident that the rating of the transmission will vary with the motor connections and may also be complicated by the shunting of motor fields. In many cases, however, motor combinations are arranged so that for all practical purposes the only short time limit is due to heating of traction motors in the low-speed connection. It may sometimes be necessary to check heating of generator fields in cases of sustained high generator voltage and corresponding high locomotive speed. Besides the standard method of short time rating as given by the A. I. E. E., other methods are used, generally to simplify testing procedure. In all cases, however, methods of prorating and coordinating test ratings can be developed which are similar.

In many service applications of a Diesel-electric locomotive, the limiting condition can be approximately represented by a moderate load of fairly long duration, followed by a heavy load for a short time, after which the load drops and allows the equipment to cool. Such a condition is represented by the thermal capacity rating. If the equipment temperature is 100 deg. C. and a heavy load of 160 per cent of continuous rated current is put on, the thermal capacity rating is directly equal to the number of minutes required for the peak temperature to reach 160 deg. C., which is considered the limit. If, as usual, the conditions are different, Fig. 4 may be used for approximate proration.

(a) If the current is not 160 per cent of the continuous rating, the curves give a new thermal capacity, corresponding to the particular current involved.

(b) If the initial temperature is not 100 deg. C. and the final peak temperature not 160 deg. C., it is usually sufficient for practical purposes to assume that the thermal capacity rating, in sec. per deg. will apply to any practical temperature range.

Fig. 3 shows a typical heating curve of temperature against time, on which *AB* shows the range covered by the thermal capacity rating. If the initial temperature is above 100 deg. C., and we assume the same constant rate of heating, we will get a conservative result since the calculated peak temperature will be higher than the true one.

On the other hand, if the motor starts cold, the serious peaks are generally due to very high currents and the greater the currents the more nearly constant is the rate of heating, so that the method, although not exact, has considerable practical value.

To make a proper application, the temperature rise of equipment at reduced loads should be known, so that it can be estimated from what temperatures the rises due to peak loads will start. Such information can usually be estimated by motor and generator designers without much difficulty.

# The Combustion Gas Turbine

## Part I

**By F. K. Fischer***
**and**
**C. A. Meyer**

THERE are many future uses of the gas turbine because it potentially promises higher efficiency at very high temperatures than most engines and prime movers used today. Future applications range from electric power generation to power-plants for propelling airplanes, trains and ships.

The advantages of the gas turbine cycle as compared to the conventional steam system include: (1) no boiler is used; (2) water is not required for the simple open-cycle system; (3) promises greater efficiency improvement at high temperature and (4) high hp.-per-lb. output for short

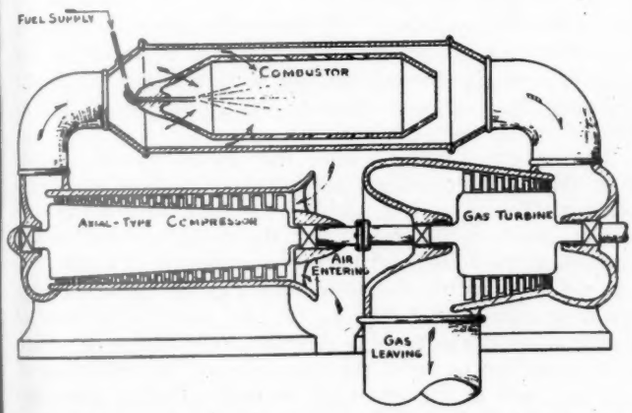



Fig. 1—Diagrammatic view of the major gas turbine cycle elements

life applications. Present disadvantages include: over-optimism; fuel limited to high grade oils instead of low grade oil and coal; little field experience and need of time to complete technical developments in metallurgy and component parts of the gas turbine system. To a large degree, the future application of the gas turbine depends upon developments in the field of metallurgy, aerodynamics, combustion and heat exchange. Present knowledge in these fields permits building and operating simple gas turbines for certain purposes. Experience with some of the simple forms of gas turbine plants has been successful and encouraging. In the post-war period, industry will benefit from the developments now being engineered for national defense. These devlopments will accelerate the application of gas turbine plants to new and larger fields.

Progress toward a practical gas turbine power unit has been delayed because the thermal efficiency required to make it competitive with the highly developed steam cycle required: (1) operation above 1,000 deg. F; (2) a highly efficient compressor; and (3) a highly efficient turbine. Two seemingly unrelated industries have recently made important contributions to help solve these problems. Metallurgists, in developing materials for superchargers have produced alloys that are expected to withstand at least 1,200 deg. F. continuous service at the low operating pressures encountered in gas turbine work. Aviation and wind tunnel research on airplane propellers and wings have contributed fundamental aerodynamic data on which high efficiency compressor designs are based. The research in these two industries plus the accumulated steam experience of many years has made possible the necessary high-efficiency turbine and compressor elements and solved many of the mechanical problems involved in gas turbines.

The open cycle combustion gas turbine eliminates a big and expensive step in providing power to drive generators or machinery. In its power cycle, all the hot gases of combustion go straight to the turbine, thus eliminating the steam boiler. By contrast, in the highly developed steam cycle, the fuel energy must be converted to steam, at a comparatively low temperature, before expending its energy in the turbine. In the combustion gas turbine system of power generation there are two basic cycles—the open cycle for moderate capacities and the closed-cycle for very large units.

The gas turbine employs the simplest power cycle known, consisting of three major elements: a compressor, a combustor and a gas turbine. A general idea of what the elements are like are shown as longitudinal sections in true relative size in Fig. 1. The gas turbine resembles the straight reaction, non-condensing steam turbine. Gas turbine blades look more like air foil sections than reaction steam turbine blades due to the small pressure drop and large gas volume involved. The

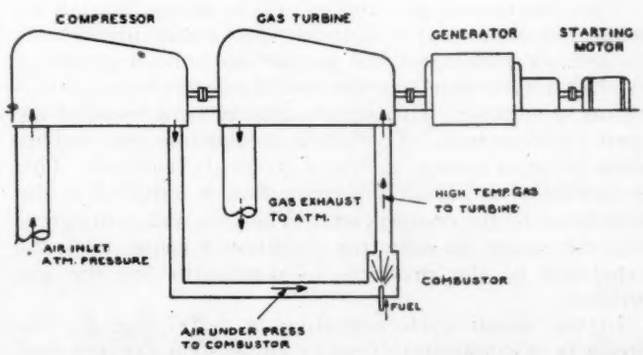



Fig. 2—Simple open combustion gas turbine cycle

axial-flow compressor also resembles a straight reaction turbine, with the gas to be compressed passing axially through the compressor. The action of the blades in the axial flow compressor is the reverse of the action of expansion in a reaction turbine. This physically small compressor handles the large volume of gas efficiently. The combustor is the burner in which the chemical energy of the fuel is converted into heat energy, by burning the fuel with sufficient excess air to obtain the desired temperature. The hot product of combustion from the combustor is the gas, which, expanding to a lower pressure

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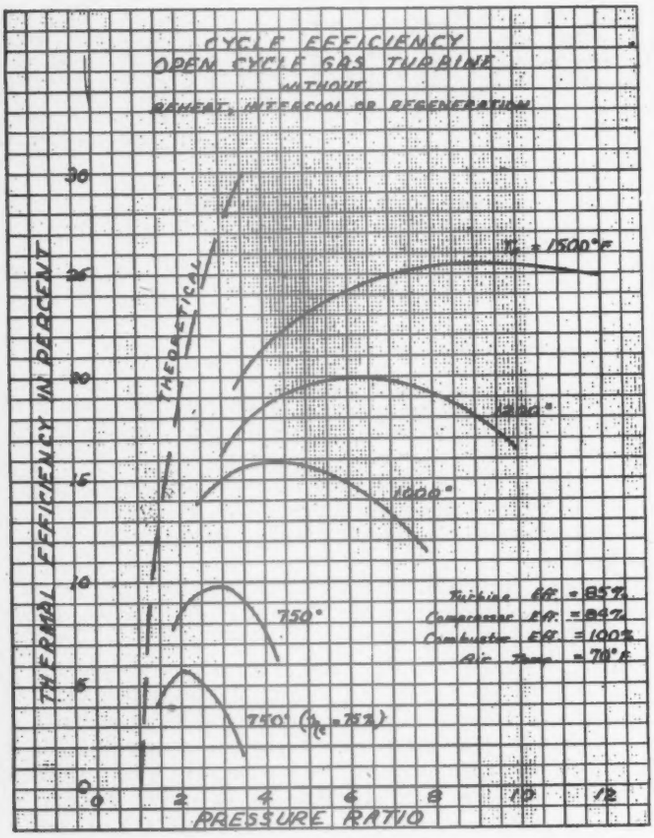



Fig. 3—Thermal efficiency compared to pressure ratio

and temperature in the gas turbine, converts some of its heat energy into mechanical energy at the turbine shaft. The combustor is relatively small since its rate of heat release is many times that of the conventional steam boiler which, in addition to burning fuel must transfer the heat through tube walls to generate steam.

## How the Cycle Works

The combustion gas turbine cycle in its basic form comprises three major elements previously mentioned: compressor, combustor and gas turbine; plus a generator or shaft for transmitting the useful power output, and a means of starting. This simple arrangement is called the open cycle system. To start a combustion gas turbine some external means, such as a motor, is required. This is necessary as the air for combution is supplied to the combustor by the compressor. When the unit is in operation the energy to drive the compressor comes from the expansion of the products of combustion in the gas turbine.

In the simple cycle operating at 1,200 deg. F., the products of combustion (gas) contain some 600 per cent excess air. This gas is expanded in the turbine and exhausted to the atmosphere. No intermediate fluid is used as in the steam cycle, where fuel is burned and releases chemical energy as hot products of combustion which pass through a steam boiler to generate steam for the steam turbine. The steam generator, or boiler, is the biggest single element in the steam power plant. In the gas cycle a compressor and combustor replace the boiler, resulting in a much smaller and more compact power plant. Because the simple open combustion gas cycle does not require cooling water, no steam condensor such as used in the condensing steam cycle is needed and plants may be located without regard to a suitable source of cooling water.

Although the first patent was taken out over 150 years ago, early inventors were unsuccessful in getting units efficient enough to drive their own compressor. The cycle was perfectly sound, but, these early inventors lacked materials to withstand the necessary high temperature plus turbines and compressors of suitable efficiency.

Today the story is changing. Materials are capable of operating at high temperatures. The maximum temperature employed is largely a question of the useful life. For a life of relatively few hours, such as might be satisfactory for some military needs, temperatures of the order of 2,000 deg. F. are allowable. Heavy duty or long life applications are limited to much lower temperatures. The tremendous advances in metallurgy for the war effort, will undoubtedly produce materials capable of operation at temperatures which we would not have attained for many years under a normal peace time development.

The combustion gas turbine requires tremendous volumes of gas. The axial flow compressor, small in physical size, efficiently handles the large volumes required. Until recently the axial flow compressor was largely an unknown quantity. Today, the advancement in knowledge of proper blade shapes and research in the development of efficient air foil sections have given the designer the necessary tools to design and build highly efficient axial flow compressors.

In the gas turbine cycle, the useful power output depends upon obtaining relatively high turbine and compressor efficiency. The useful net output is the difference of two fairly large quantities: the total turbine output and the work consumed by the compressor in compressing the air. With the system of Fig. 2 operating at a top temperature of 1,200 deg. F.; for each useful unit of power output, the turbine develops 3.95 units of which 2.95 is needed to drive the compressor. A reduction of one per cent in the efficiency of each of these elements reduces the useful output by seven per cent. The useful output decreases sharply as the top temperature is lowered.

In Fig. 3 the simple gas cycle thermal efficiency is plotted as a function of the pressure ratio for several turbine inlet temperatures of the combustion gas. Pressure ratio is the compressor discharge pressure divided by the compressor inlet pressure, which is 14.7 lb. per sq. in. absolute in the open cycle. The curves are based on these efficiencies: Turbine 85 per cent; compressor 84 per cent; combustor 100 per cent; and air inlet temperature of 70 deg. F. The 750 deg. F. curve is plotted for two different compressor efficiencies showing the

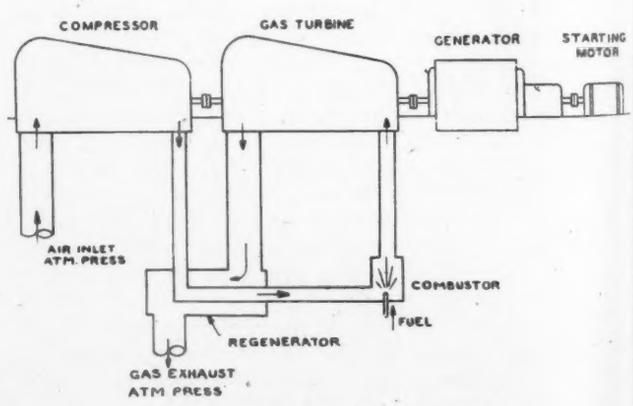



Fig. 4—Open cycle with regeneration

effect of change in efficiency of one of the elements. A reduction in compressor efficiency of nine per cent cuts the cycle efficiency almost in half. The relatively low pressure ratios at which maximum efficiency is obtained, around six for 1,200 deg. F., means that relatively low turbine inlet pressures exist in the open cycle, under 100 lb. per sq. in. absolute. Low pressure results in large gas volume and relatively large turbine blade dimensions.

Engineers have been experimenting with this combustion gas cycle for many years. In Europe, because of economic conditions engineers attempted to develop it as soon as materials and compressors even remotely offered a possibility of building successful units. In this country, much of the recent development is of necessity not published because of Government security reasons. However, in the literature there has been a considerable description of pre-war applications in Europe. These plants are inferior in efficiency to what can be built today, but they are apparently giving satisfactory results. Interesting applications include a turbine locomotive, electric generating set, compressor drive for Velox boiler, refiners drives and airplane propulsion.

## Regenerating, Intercooling, and Reheating Aid Efficiency

As shown in Fig. 3 the efficiency of the simple open gas cycle is low unless extremely high temperatures are

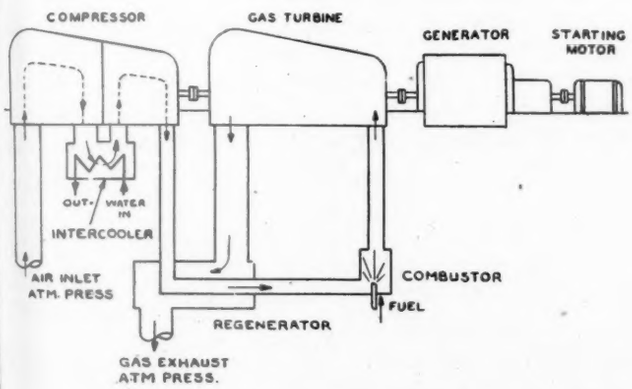



Fig. 5—Open cycle with intercooling and regeneration

used. However, there are three practical ways of greatly improving the gas cycle efficiency. They are: regenerating, intercooling and reheating. The regenerating gas cycle is a cycle in which a heat exchanger (regenerator) transfers some of the heat from the relatively hot exhaust gases leaving the turbine to the air before it enters the combustor. (Fig. 4.) Heating the air by exhaust gases reduces fuel consumption and improves the cycle efficiency. The amount of heat obtained from the exhaust gas depends on the size of the heat exchanger. This is an economic problem in which gain in efficiency is balanced against cost of heat exchanger surface. Calculations indicate that the economic size of the heat exchanger will limit the regenerating cycle, at 1,200 deg. F. inlet temperature, to approximately 75 per cent recovery of the heat available from the turbine exhaust gases. This economic size will be about 0.30 cu. ft. of heat exchanger volume per kw. of capacity.

Efficiency is further improved when intercooling is added to regeneration as shown in Fig. 5. As the name implies, intercooling removes the heat of compression from the air passing through the compressor. Water, circulating through the intercooler cools the air, and is a necessary part of the cycle. By intercooling, the compressor work is reduced because the colder air has smaller volume. Other conditions remaining the same, one stage of intercooling will reduce the compressor work by some 15 per cent. This increases the portion of the turbine capacity available as useful output and improves the cycle efficiency. A large number of intercoolers is ideal but probably only a few stages will be practical.

The third method of improving efficiency, reheating, consists of adding heat to the gas as it passes through the turbine as shown in Fig. 6. The gas turbine reheat cycle

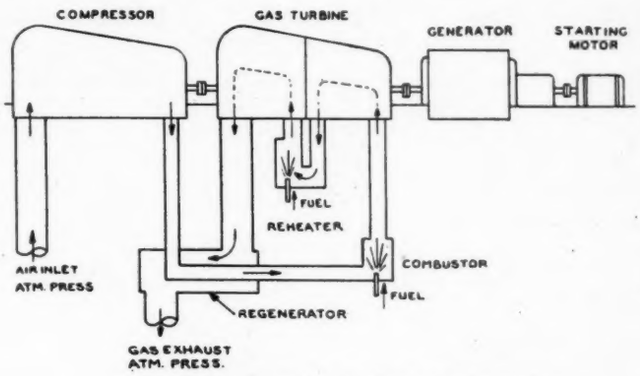



Fig. 6—Open cycle with reheating and regeneration

is the same principle as the reheat cycle used in many steam plants. In practice it will bear little resemblance. Reheating in the gas turbine will consist of burning fuel directly in the gas (approximately 85 per cent air) passing through the turbine. The quantity of large steam piping and considerable heat transfer surface in the heat exchanger of the steam reheat cycle will be replaced by a reheating combustor which may possibly be placed inside the gas turbine casing proper. Here again, the practical number of reheats is limited. One reheat is illustrated in Fig. 6.

Reheating and intercooling increase the amount of useful energy per pound of working gas passing through the system, thus reducing the number of pounds of working medium circulated. Therefore, the size of piping and blade path in the compressor and turbine are reduced. In combination with a regenerator, the terminal difference across the heat exchanger is greater for a given size exchanger, or a smaller heat exchanger transfers the original amount of heat. In partial load operation they increase the partial load efficiency considerably.

## Various Cycle Combinations Compared

The combination of regenerating, reheating and intercooling is shown in Fig. 7. Different cycle arrangements are compared in Table I on the basis of the power

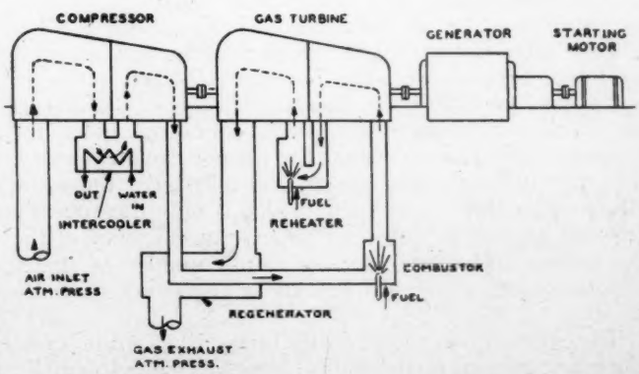



Fig. 7—Open cycle with intercooling, reheating and regeneration

requirements of each major element, with the capacity of the generator as unity. The efficiency of each cycle arrangement at 1,200 deg. F. is given, the temperature in degrees Fahrenheit, and the absolute pressure at different points in each cycle.

The thermal efficiency of the open cycle gas turbine for various combinations of regenerating, reheating and intercooling is shown in Fig. 8. This gives the relative value of these modifications and a general idea of possible applications of this cycle. The temperature range of

**Table I—Effect of Different Open Cycle Arrangements on Each Major Element**

| Item | Simple cycle | Cycle with regeneration | Intercool and regenerate | Reheat and regenerate | Intercool reheat regenerate |
|---|---|---|---|---|---|
| Figure No. | 2 | 4 | 5 | 6 | 7 |
| Input in fuel | 4.95 | 3.75 | 3.43 | 3.55 | 3.11 |
| Turbine rating | 3.95 | 2.95 | 2.80 | 2.88 | 2.55 |
| Compressor power | 2.95 | 1.95 | 1.80 | 1.88 | 1.55 |
| Useful output | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Per cent eff. at 1,200 deg. F. | 20.2 | 26.6 | 29.2 | 28.1 | 32.2 |
| Gas temp. in deg. F. at | | | | | |
| Turbine inlet | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
| Leaving reheater | .. | .. | .. | 1,200 | 1,200 |
| Turbine exhaust | 635 | 790 | 695 | 920 | 865 |
| Leaving regenerator | .. | 455 | 350 | 560 | 520 |
| Air temp. in deg. F. at | | | | | |
| Compressor inlet | 70 | 70 | 70 | 70 | 70 |
| Leaving intercooler | .. | .. | 70 | .. | .. |
| Leaving compressor | 490 | 340 | 230 | 440 | 405 |
| Entering combustor | 490 | 680 | 575 | 800 | 750 |
| Press. lb. per sq. in. abs. at | | | | | |
| Compressor inlet | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 |
| Compressor discharge | 88.2 | 51.5 | 73.5 | 73.5 | 102.9 |
| Turbine inlet | 88.2 | 50.2 | 71.7 | 71.7 | 100.4 |
| Turbine exhaust | 14.7 | 15.1 | 15.1 | 15.1 | 15.1 |

1,000 deg. F. to 1,500 deg. F. was chosen because applications at temperatures much below 1,000 deg. will undoubtedly be impractical. Early applications for heavy duty long life apparatus will probably not exceed temperatures of 1,200 deg. F. with 1,500 deg. F. and higher limits awaiting future developments in metallurgy.

The temperature of the inlet air to the compressor has a marked effect on the cycle efficiency. In contrast to steam plants the colder this inlet air the higher the cycle efficiency and capacity. In the simple open cycle, changing the inlet air temperature 10 deg. F. changes the cycle efficiency 0.74 points or approximately three per cent per 10 deg. F. change. The effect on capacity is approximately four per cent per 10 deg. F. change. The effect on cycle thermal efficiency of inlet air temperature, on the different cycle arrangements with a top temperature of 1,200 deg. F. is plotted in Fig. 9.

## Steam and Combustion Gas Cycles Compared

Because steam is the most widely used medium for transferring heat into mechanical energy, a comparison of the steam cycle and the gas cycle may help in judging the gas cycle and its possibilities. In judging the efficiency of power cycles, a 100 per cent thermal efficiency is not obtainable as the temperature of the cold body is far above the absolute zero of temperature. The Carnot cycle is theoretically perfect cycle, and no cycle operating between the same hot and cold body temperatures can have a better thermal efficiency. The best any cycle can hope to do, when operating under the same conditions, is to obtain the Carnot cycle efficiency. The gas turbine cycle can theoretically give the same efficiency as the Carnot cycle. This is only theoretically possible because it requires 100 per cent efficiency of the gas turbine and compressor, an infinite number of stages of intercooling and reheating, and a regenerator infinite in size.

The steam cycle theoretically offers the Carnot cycle efficiency only up to the critical pressure (705.4 deg. F; 3,206 lb. per sq. in. absolute). Above this temperature, the gap between the steam cycle and the ideal cycle gradually widens as the temperature is increased. From a purely theoretical standpoint the combustion gas turbine cycle holds forth greater promise of efficiency than the steam cycle.

## Gas Cycle Holds Best Promise

Of more value are the thermal efficiencies obtainable in practical applications. Fig. 10 compares the best efficiencies obtained in large central station power plants (projected to 2,000 deg. F.) with the expected practical limit in efficiency of the large capacity closed cycle combustion gas turbine power plants. Above 1,000 deg. F. the gas cycle efficiency increases approximately three times as fast as the steam cycle efficiency for a given top temperature increase.

This curve compares the best modern large central station steam power plants with the best practical efficiencies expected of the combustion gas turbine power plants. It is expected that the gas turbine cycle efficiency will not be greatly affected by unit size, and this combustion gas cycle curve can also be interpreted as applying to open cycle gas turbine power plants of relatively small capacity. Economic steam plants for capacities around 5,000 kw. seldom exceed 25 per cent overall thermal efficiency. This would indicate a considerable efficiency advantage, in small units, in favor of the gas cycle, provided economics permit designing it for anywhere near its maximum possible efficiency.

A 5,000 kw. steam turbine is compared with a similar open cycle gas turbine in Table II. This indicates the low pressure in the gas turbine as compared with the

**Table II—Comparison of Combustion Gas Turbine and Steam Turbine**

| | Open Cycle Gas Turbine | | | Steam Turbine |
|---|---|---|---|---|
| | Simple cycle | One reheat, one intercool or regeneration | | Three stages Feedwater heating |
| | Single cylinder | H.p. turbine | L.p. turbine | Single cylinder |
| Inlet pressure, lb. per. sq. in. in absolute | 88.2 | 100.4 | 39.4 | 465 |
| Inlet temperature, deg. F. total temperature | 1,200 | 1,200 | 1,200 | 825 |
| Exhaust pressure, lb. per sq. in. absolute | 14.7 | 39.4 | 15.1 | 1 |
| Steam or gas rate, lb. per kw. hr. | 102 | 56 | | 10.5 |
| Full load flow, lb. per hr. | 510,000 | 280,000 | | 52,500 |
| Inlet volume flow, cu. ft. per sec. | 990 | 475 | ... | 24.8 |
| Exhaust volume flow, cu. ft. per sec. | 3,900 | ... | 3,250 | 6,120 |
| Ratio (exhaust volume ÷ inlet volume | 3.95 | 6.85 | | 250 |
| Turbine floor area, sq. ft. | 160 | 150 | 155 | 100* |
| Net generator output, kw. | 5,000 | 5,000 | | 5,000 |
| Approximate plant thermal efficiency, per cent. | 18.4 | 29.4 | | 23.6 |
| | (inlet air temp., 70 deg. F.) | | | |

* Turbine room only.

steam cycle. The energy per pound of gas is small and the flow of gas is very large. The large flow and low pressure to the inlet of the gas turbine gives a large volume flow which means the piping and blading of the gas turbine inlet are large compared to the steam turbine.

The ratio of exhaust to inlet volume is small for the gas turbine. This makes a balanced blade path unlike that of the steam turbine, which in this case must handle an exhaust volume 250 times as great as the inlet volume. The large blade dimensions limits the maximum net output rating of the open cycle, single flow, combustion gas turbine to approximately 7,500 kw. However, the injection of liquids presents a theoretical possibility considerably extending this limit.

*(To be continued)*

# EDITORIALS

## Postwar Air-Conditioning

Broadly speaking the term "air conditioning" may be interpreted to include preparing air most satisfactory for human use as regards freshness, humidity control and proper temperature range for both heating and cooling. The consensus of leading railway mechanical and operating officers is that railroads can enjoy an attractive passenger business after the war but, in order to do this, they must be prepared to supply modern lightweight passenger cars with all refinements in design including the latest improved types of heating and air conditioning equipment.

From a temperature standpoint, it is important that every passenger enjoy a maximum degree of comfort, this objective being by no means easy to attain. The interior of a passenger car is long, rather narrow and comparatively low-ceilinged space, which requires specialized handling in order to assure the maintenance of desired temperatures in all parts of the car and under all conditions. It is generally recognized, for example, that the sunny side of the car requires less heating in winter and more cooling in summer than the shady side and this implies consideration of the two sides of the car as separate zones with separate thermostatic circuits.

It is also quite generally agreed that the ends of the car are likely to be affected by door openings so that, in order to make passengers comfortable in seats next the door, this space must be considered as a separate zone of the car with separate temperature control. Lounge rooms must also be considered, from a temperature standpoint, as individual units of space requiring separate temperature controls.

Many improvements in air-conditioning have been developed and will be available in postwar passenger cars, this equipment probably being lighter in weight, having more cooling capacity than that previously supplied and subject to more accurate distribution of air throughout the car. Attention is being paid to the control of humidity in air-conditioned cars, particularly during the cooling cycle and the objective is to develop as simple and effective equipment as possible to accomplish this purpose. There is a genuine demand for simplicity in the operating controls, but with definite permissible variation from selected temperatures so that train crews will be able to get desired results without the need for too detailed instructions.

Indications are that postwar passenger-car heating equipment will utilize alloys of copper and steel to present the most effective possible heat distribution surfaces with due consideration for weight limitations. The increased length of passenger trains will necessitate using the new larger steam train-lines and great emphasis will be placed on eliminating all possible sources of steam waste. Wash-water heating is a necessary and important function and recent developments point to the possibility of greater simplicity, lighter weight and greater reliability in equipment for this purpose.

Basically, in summing up interesting developments for increased passenger comfort in modern lightweight equipment which will be constructed in the future, air heating and cooling equipment and controls will be designed with the objective of making every available space for passenger occupancy comfortable from a temperature, air freshness and humidity standpoint. This is in line with efforts to secure maximum space occupancy and thus obtain the fullest possible benefits from new lightweight equipment. Every passenger must be assured of full temperature comfort in every part of these new cars.

## How Low Should the Bad-Order Car Ratio Be?

For more than two years the American railroads have held the ratio of bad-order freight cars to total inventories at record lows. In fact, they have surpassed anything which was even conceived to be possible in the years preceding the war. It may be that they can continue to do so but there is also evidence to indicate this may not be altogether wise.

Dislocations in regular repair schedules caused by lack of materials and manpower, critical demands for cars, off-line cars and other factors have been common to all railroads. Efforts have been directed primarily toward keeping cars in service and to such an extent that conditions which formerly would have marked a car for at least light-repair attention have been tolerated in order that the cars might remain in service. None of these conditions were such that the cars were operated in violation of any existing safety regulations but they did involve conditions usually corrected to contribute to longer car life and to maintain them in shape —house cars especially—for high-class commodity loadings.

That such repairs have, of necessity, been neglected is plain when the number of cars in evident need of painting is used as one indicator. Another is the increasing number of steel side cars which are almost completely rusted out at the side sills. If these and other signs of

deterioration were only symptomatic of the immediate condition there would be little cause for concern. However, in normal times when such needed repairs were made all parts of the car structure received a careful inspection, particularly the running and draft gears. Such inspections often disclosed defects which were corrected then before the cars were returned to service. Many of such defects are now going undetected until they actually cause trouble, sometimes serious trouble.

Although experienced carmen recognize that there has been a decided relaxation of standards in determining what constitutes a bad-order car, and that such relaxation has been further increased by the inexperience of many of their inspectors, they are still maintaining extremely low bad-order ratios. Indeed there seems to be some disposition among managements to compete for low reported figures. This is done in the face of the obvious fact that railroad freight cars which have been taking a hammering since the war began, with a minimum of repair attention, are deteriorating. The condition is probably not yet such as to constitute a serious threat to the safe operation of the railroads but it is time to recognize that statistics as to bad-order cars are no longer a criterion of the prevailing standards of maintenance.

## Ten Years of Streamlining

A decade has elapsed since the first streamliners of lightweight construction for high-speed service made their appearance on American railways. Beginning with the three-unit articulated train of aluminum-alloy construction, which was delivered to the Union Pacific in February, 1934, by the Pullman Car Manufacturing Company, and the stainless-steel three-unit articulated Pioneer Zephyr, which the Chicago, Burlington & Quincy received from the Edward G. Budd Manufacturing Company, in April, 1934, the decade ended with the railroads in possession of 143 trains, all of which would be operating today with completely streamline equipment were it not for the extraordinary traffic conditions produced by the war. Indeed, had the war not intervened, the number of such trains would undoubtedly have been considerably greater. Including the lightweight streamline cars not assigned specifically to completely streamline trains, more than 2,000 car units have been built since the first trains made their appearance.

But the significance of this development is not alone measured by the rapid multiplication of train and car units. It includes all the innovations in seating, in ventilation, heating and cooling, in riding qualities, in the suppression of noise, and in styling which have made most of the passenger cars more than ten years old obsolete. It includes the new approach to motive-power problems which the success of the high-speed trains has brought about.

The popular success of these trains from the very outset has directed engineering development into channels from which results are only beginning to flow. The passenger-car truck has been the subject of intensive study, first, to determine the fundamental relationships of car body to track and of the interposed parts to both, and, second, to develop the best practicable approach to the ideal in a truck assembly. Tangible results of this work will be seen after war restrictions on materials and manpower are off. Other fields of development, the practical effects of which will be felt after the war, are car heating, air conditioning and lighting. Braking of high-speed trains is not an unsolved engineering problem, but as higher speed schedules become more and more prevalent, more and more trains will be controlled by the electro-pneumatic type brake with its faster and smoother action. Disk brakes are also ready to render an increasing service, thereby relieving the severity of wheel-operating conditions on high-speed trains. The improvement of coach-seat comfort has recently become the object of scientific investigation.

The influence of the streamliner has been as great in relation to motive power as it has in relation to those features of these trains with which the public comes in direct contact. Beginning with the 600-hp. Pioneer Zephyr of the Burlington, there are now 224 Diesel-electric passenger locomotives ranging in prime mover capacities from 1,000 to 6,000 hp. operating on 22 railroads in the United States. Many of these locomotives, like the trains with which they are associated, have established records of high availability.

The outstanding contribution of these trains with respect to motive power was in the relation of train weight to horsepower for high-speed schedules. With passenger coaches weighing from 60 to 80 tons and sleeping cars not far from 90 tons each, trains of 1,000 to 1,200 tons were not uncommon on some of the best schedules in the country during the years prior to the advent of the lightweight equipment. Such trains were being handled by locomotives developing from 3,000 to 4,000 indicated horsepower which provided no more than 2.5 to 2.75 hp. per ton of gross ton weight. The streamliners demonstrated the importance of reducing weight if faster schedules were to be maintained. The first two streamliners had about six prime mover horsepower per ton of train weight and a number of the later and larger trains had from four to five prime-mover horsepower per ton of train weight. The A. A. R. study to determine the maximum drawbar horsepower required to operate a 1,000-ton passenger train at a speed of 100 miles an hour on level tangent track, undertaken in the fall of 1938, developed calculated speed-distance curves for the acceleration of a 1,000-ton train with a locomotive developing a maximum of 5,000 drawbar horsepower. Over 34 miles are required to accelerate the train to 100 miles an hour, 29 miles of which it takes to lift the speed from 80 miles an hour to 100 miles an hour. When it is con-

sidered that 5,000 drawbar horsepower, developed at high speed requires well up toward 6000 indicated horsepower, the value of weight saving to future passenger service is evident.

## The Possibilities of the Combustion Gas Turbine

A more or less permanent subject of discussion in connection with the operation of the railroads is that of the most suitable type of motive power to use for handling trains. Motive power engineers, whether in the service of the railroads or connected with those whose business it is to build locomotives, usually approach this question from the standpoint of a particular type of power in which they have reason to be interested. In this respect, they differ from those in the operating department for a prime consideration of those upon whom rests the responsibility for moving trains is not so much what type of motive power to use but whether or not there is an adequate supply of unfailing hauling power when and where it is needed.

Several times in the history of the railroads it is appeared that the supremacy of one type of motive power was in the descendency as witness the period when the eventual elimination of the steam locomotive was predicted. Once it was electrification, and electrification found its place; today it is doing an important job in that sphere of railroading to which it is best suited. Likewise, the Diesel-electric locomotive entered the picture and because of a combination of circumstances it is finding its place in the transportation picture more rapidly than was the case with the electric locomotive. Neither has displaced steam but both will eventually influence the total number of steam units in service.

For a number of years the eyes of many motive power engineers have turned toward the steam turbine locomotive but because of certain limitations of space the steam turbine has been handicapped by difficulties that are not too simple to overcome.

Within recent months we have heard a great deal about the combustion gas turbine and the fact that the Swiss Federal Railways has had a locomotive of this type in service for many months has aroused the curiosity of many in the railroad field as to the possibilities of this type of prime mover for service on American railways. (A description and discussion of the aforementioned gas turbine locomotive appeared in this publication in February, 1943, issue). Since then interest in this type of power has become sufficiently general that we feel justified in presenting in this issue an article descriptive of several arrangements of the combustion gas turbine some of which have direct possible application in the field of railroad motive power and some of which have relation only to marine and stationary power plants.

The article appearing on page 215 is the first part of a comprehensive discussion of the principles and application of the combustion gas turbine. It should be of interest to those who want a background knowledge of this subject. The various applications of this prime mover which are described in the article range from the simple open cycle, which in itself may be suitable for application in locomotive service were it not for its rather low efficiency, to the more complicated applications involving reheating and regeneration. Of the various types of potential applications described in the article the open cycle with regeneration is the one which appears at the moment to have the immediate possibilities in the locomotive field.

The gas turbine locomotive appears to have several advantages which should cause it to find a place in the railroad picture of the future. Some of them are: adaptability either to coal or oil; moderate cost per horsepower (greater than steam but less than Diesel); efficiency proportionate to cost; high starting tractive force; high potential speed; full-power braking; fuel cost comparable with Diesel; low maintenance and lubrication costs and finally the fact that only negligible amounts of water are required in its operation.

Whatever its disadvantages may be will show up as experience broadens. At the moment one of the major ones seems to be related to a question of materials suitable for high operating temperatures. The developments of the war in alloys will probably offer a solution to this problem and as the metallurgy advances the inherent advantages of the gas turbine may become more pronounced.

## NEW BOOKS

GUIDE TO WELDABILITY OF STEELS. *Published by American Welding Society, 33 West Thirty-ninth street, New York 18. 89 pages 6 in. by 9 in. Price $1.00.*

This guide is intended to present to welding engineers a system of ductility predetermination and its preservation in the heated zone of higher carbon and low-alloy steels during welding. It is divided into two sections, the first devoted to a general explanation of the entire problem of ductility adjacent to welds and the second serving as an instruction manual in the application of the system in selecting steels and predicting the welding conditions which must be met to maintain the desired ductility in the heated zone. Loss of ductility next to a weld is the result of hardening due to too great a rate of cooling in the welding operation. Since the rate of cooling is determined by the rate of heat input (current, voltage and speed) and the rate of heat extraction (mass and temperature of the base metal), it was possible to prepare tables so arranged that the rate of cooling for any common welding condition could be read directly. These tables are most important to the average welding engineer who will take the time to familiarize himself generally with the informational and instructive material given in the text.

# With the Car Foremen and Inspectors

**Havelock Shop Builds**

# New Cars for the Burlington

Steel car parts temporarily stored under the gantry crane just west of the blacksmith shop

**Heavy repair work and repairs to roadway equipment also handled—4,763 cars turned out in 1943—Shop for fabricating car material added late in 1942**

IN accordance with its policy of concentrating equipment maintenance at a minimum number of well-equipped shops, the Chicago, Burlington & Quincy now makes heavy locomotive repairs primarily at two stops located at West Burlington, Iowa, and Denver, Colo. Closing of the extensive locomotive maintenance facilities at Havelock, Neb., made this shop available for other use and it is now employed for new freight-car construction, and heavy rebuilding and repair of freight cars for the Burlington system. In addition, heavy repairs for all roadway equipments, all air-brake work, both locomotive and car, and journal-packing and oil reclamation for Lines West are handled at this shop.

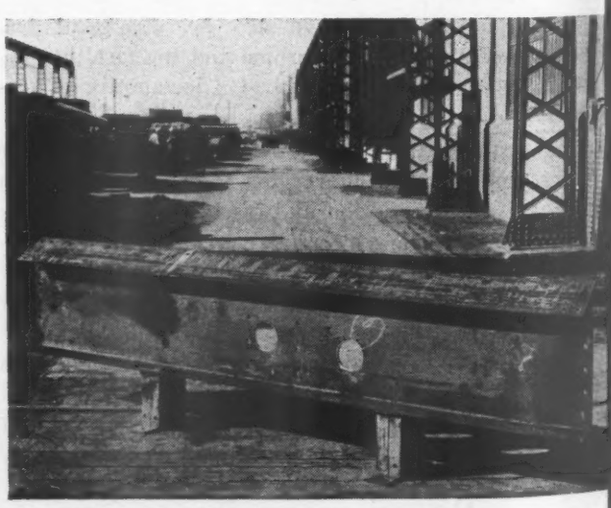
The Havelock shops, as now equipped, include all of the steel car shop machinery formerly used at the Galesburg, Ill., steel car shop which has been closed. This machinery is installed in the blacksmith shop at Havelock where the main locomotive shop building is used for fabricating car parts and assembling freight cars. The original erecting and machine shop building is now a paint shop, also used in part for repairing the larger units of roadway equipment. There are also three large dry kilns and a modern mill-room so that all lumber shipped to Havelock for use in connection with freight-car work is kiln-dried and milled at this shop.

Between 500 and 600 people are employed in all shop departments at Havelock, including 100 women, with multiple-shift operation on the spacing punches and certain fabrication work. There are about 300 employees in the stores department. During 1943, the production record of this shop was as follows: New cars built, 1,050; cars converted, 284; cars repaired, 3,169; wrecked cars repaired, 260; grand total, 4,763 cars.

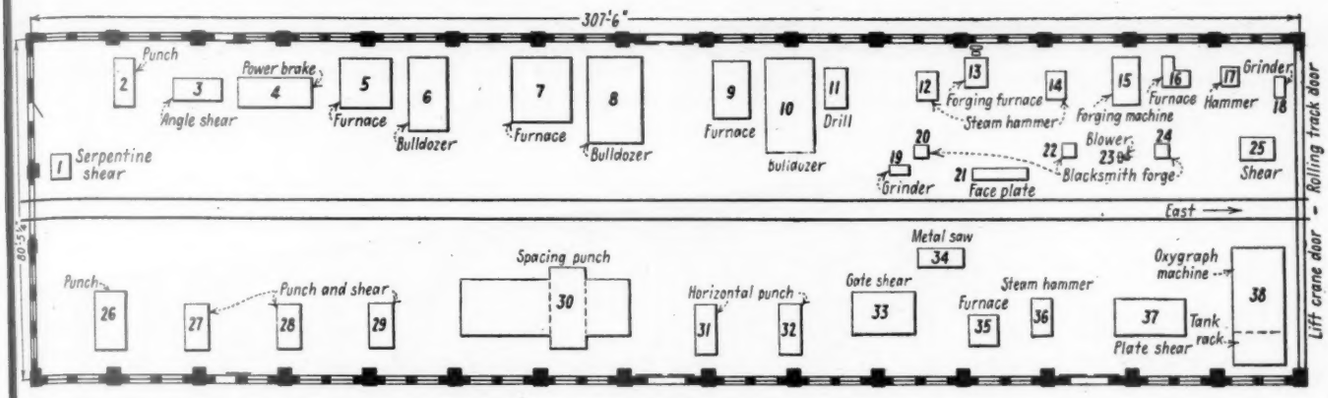
### Havelock Shop Converted for Car Work in 193

The original Havelock locomotive shop, placed in operation in 1893, was first converted into a car shop in 1931, the Galesburg steel car plant being consolidated with it and the machinery moved to Havelock in October, 1942. By January 2, 1943, all machinery was installed and the work of fabricating car material was initiated.

The steel car-shop machinery, now used in the old 80½-ft. by 307½-ft. blacksmith shop is located as shown in the drawing and includes the individual items given in the accompanying table. The largest machines in this group include three Williams & White bulldozers, a spacing punch and three punches and shears supplied by the same manufacturer, two Hilles & Jones horizontal



Car body bolster for hopper cars utilizing I-beam for the main strength member




Floor plan showing arrangement of machinery in the old blacksmith shop where steel car materials are prepared

## Machine Equipment in the Blacksmith Shop of the C. B. & Q. at Havelock, Neb.

| Number | Type of Machine | Electric motor hp. | Number | Type of Machine | Electric motor hp. |
|---|---|---|---|---|---|
| 1 | ½-in. Serpentine shear (Ryerson) | 5 | 19 | Double head grinder | 5 |
| 2 | Single-end punch (Williams & White) | 5 | 20 | Oil fired blacksmith forge | — |
| 3 | Angle shear (Schulz & Newman) | 10 | 21 | Face plate | — |
| 4 | Power brake (Dreis & Krump) | 15 | 22 | Oil fired blacksmith forge | — |
| 5 | Furnace with blower and motor (Ferguson) | 10 | 23 | Oil forge blower | 3 |
| 6 | No. 27 bulldozer (Williams & White) | 25 | 24 | Oil fired blacksmith forge | — |
| 7 | Furnace with blower and motor (Ferguson) | 20 | 25 | Shear (Cleveland) | 7½ |
| 8 | No. 9 bulldozer (Williams & White) | 50 | 26 | Single-end punch and shear (Beatty) | 20 |
| 9 | Furnace (Ferguson) | — | 27-28-29 | Single-end punch and shear (Williams & White) | 7½ |
| 10 | No. 297 bulldozer (Williams & White) | 50 | 30 | Spacing punch (Williams & White) | 25 |
| 11 | No. 416 Drill (Baker) | 7½ | 31 and 32 | Horizontal punch (Hilles & Jones) | 7½ |
| 12 and 14 | 1,500-lb. Steam hammer | — | 33 | Gate shear (Bertsch) | 20 |
| 13 | Forging furnace with blower and motor | 3 | 34 | Metal saw (Higley) | 5 |
| 15 | Motor driven forging machine (Ajax) | — | 35 | Furnace with motor and blower | 3 |
| 16 | Furnace with blower and motor | 5 | 36 | 2,500-lb. Steam hammer (Chambersburg) | — |
| 17 | No. 4 hammer (Beaudry) | 5 | 37 | Plate shear (Williams & White) | 15 |
| 18 | Double head grinder | 3 | 38 | Shape cutting machine with tank rack (Oxweld) | — |

Looking east through the newly-equipped steel fabricating shop of the C. B. & Q. at Havelock, Neb.

punches, a Bertsch gate shear and three steam hammers. A full complement of additional equipment required in a steel car shop is installed including necessary furnaces, floor grinders, forges and an Oxygraph cutting machine.

The flow of material through the blacksmith shop is in at the east end, past the various machines and out the west end, largely as finished sheets, shapes and pressings ready for assembly and fabrication into individual car parts. Power lift trucks and tractors are largely used for transferring materials and heavy parts are moved by the 10-ton 80-ft. overhead traveling crane moved from Galesburg. The provision of a center track enables cars of material to be run into the shop and distributed to the proper machines where work is to be done. All essential machines are equipped with jib cranes for the handling of heavy material to and from the machines.

The east end of the Havelock blacksmith shop has been revised in construction to include an electrically operated lift door in the upper part which permits the crane to move out of the shop on a 300-ft. extension of the crane runway, thus covering steel storage space just east of the shop. The center track door, 19 ft. high by 20 ft. wide, is in two parts and operates easily on rollers. A small hinged drop door in line with the crane cab gives a suitable opening for this part of the crane. The crane doors on this end of the shop are electrically operated by push-button control from the ground and can be opened or closed in a little over one minute.

Steel car materials, passed out the west end of the blacksmith shop, are transferred by a 40-ton double-hoist gantry crane to temporary storage or direct to the main car shop building where they are taken in at the west end and fabricated and assembled into the completed cars. In this shop, which comprises the machine and erecting shop built in 1910, the overhead traveling cranes are a great aid in handling material and expediting shop work. A new gantry, installed over the stripping track east of the main car shop, helps in handling all heavy car parts and speeds up the stripping operation. In the machine bay of the main car shop, two additional spacing machines are installed. There are also one 50-ton pit riveter, and one 80-ton riveter for sides and center-sill riveting. This bay is served by one 6-ton and one 10-ton traveling crane.

One of the illustrations shows typical stacks of shaped car parts located under the gantry crane west of the blacksmith shop. These stacks include such materials as door reinforcing angles for coal cars, hinge-butt angles, inside and outside hopper sheets, side braces, hood sheets, etc.

One unusually interesting job, now being done at Havelock shops, is making hopper-car body bolsters of a structural I-beam, as indicated in the view of one of these bolsters resting on the walkway west of the shop. This bolster meets all A. A. R. strength requirements and constitutes an ingenious design, made possible by having the right kind of shop machinery available to do what is desired, and by the development of reliable welding equipment and processes.

Referring to the illustration, the general construction will be evident. The I-beam web is bent cold near one flange in a bulldozer to give this flange the proper angle for the floor slope. Each of the two top side bearings consists of two channels placed back to back, riveted and welded together, the side bearings in turn being welded to the I-beam bolster by the electric process. Service tests have demonstrated the strength of this bolster which is lighter and costs less than the usual type built-up pressed-steel car body bolster construction.

One of the 70-ton composite ballast cars which was built at Havelock shops in 1943

A 50-ton composite hopper—The output of these cars at Havelock is now 16 cars a day

## Air Brake Questions and Answers

### Installation and Maintenance of Axle Generators

247—*Q.—Explain how to make a brake application.*

A.—To make a brake application move the brake valve handle to the right, the farther the movement the greater the application up to a maximum of 75 lb. in the full self-lapping notch. As the handle is moved to the right the cam moves the dog, pusher and attached lever, the ends of which are positioned on the inlet valve and the exhaust valve. The spring pressure plus the air pressure

acting to hold the inlet valve closed is stronger than the spring pressure to hold the exhaust valve open, therefore, the first movement of the handle cam to move the floating lever causes the exhaust valve to close, cutting off the brake valve exhaust *Ex*. Further movement of the brake valve handle to the right causes additional movemen of the floating lever which now fulcrums on the closed exhaust valve and opens the inlet valve, allowing feed valve air from passage 21a to flow into cavity *B* of the brake valve and thence through connection *11* to the control pipe. As air pressure builds up in cavity *B* it acts upon the spring loaded piston which forms the exhaust valve seat, and moves the piston and exhaust valve against the force of the regulating spring, the exhaust valve thus remaining closed. The exhaust valve end of the floating lever moves with the exhaust valve and piston until the regulating spring is compressed sufficiently to balance the cam pressure on the lever, after which the application end of the lever moves away from the inlet valve which is then closed by its spring. In this manner the self-lapping unit operates to quickly and accurately build-up pressure in the control pipe corresponding to the position of the brake valve handle in the application zone.

## Shop Testing Of Hand Brakes

Before repaired hand brakes are returned to service on the Reading they are tested on a special rack designed to record the capacity of each unit when it is drawn up hand tight. As the brake is drawn up it operates a piston in a closed cylinder serving to compress the air in the cylinder. The pressure created is read on a gauge which is calibrated in hundreds. Conversion figures used for the gauge readings to give the load which would be developed at the brake cylinder piston when the brake is applied on a car are shown in the table.

**Gauge readings on this test rack can be converted to indicate loads developed by hand brakes at the brake-cylinder piston**

**Conversion Table Developed for Handbrake Testing Rack**

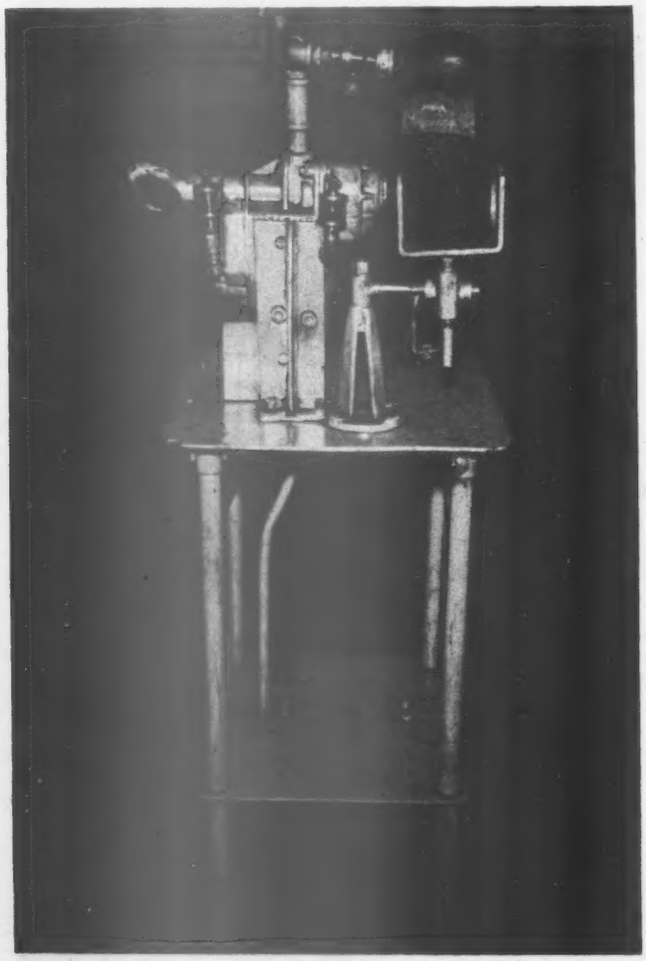
| Gauge reading | Approximate pressure at brake cylinder piston, lb. |
|---|---|
| 100 | 660 |
| 200 | 1,300 |
| 300 | 2,000 |
| 400 | 2,600 |
| 500 | 3,300 |
| 600 | 5,000 |
| 700 | 5,600 |
| 800 | 6,300 |
| 900 | 7,000 |
| 1,000 | 7,600 |

* * *

**Oxygraph C M-23 gas-cutting machine shaping hopper-car outside door sheets (¼-in. sheets, 15 at a time) at the Havelock, Neb., car shops of the C. B. & Q. These sheets will be used in a program for building 1,000 hopper cars —The production is at least 4 to 1 over the coping and shearing method which would otherwise be used**

## Brake-Cylinder Piston-Rod Polisher

When AB brake cylinders are overhauled it is frequently necessary or desirable to polish the piston rod. Although this work can be done satisfactorily by hand, a much faster and more convenient method is to use a machine similar to one designed and placed in operation at the Reading car shop, Reading, Pa. A shaft for a polishing brush was attached to an air motor and the assembly firmly mounted on a movable work bench. Guide rings placed in front of the brush shield are of the proper



Piston rods are polished before reassembly of AB cylinders

diameter to receive and hold the piston rod in position at the brush. While the operator rotates the rod by hand during the polishing action a foot-pedal control starts and stops the motor which rotates the brush.

## Removing Collars From Roller-Bearing Axles

A special device for removing shrink collars from roller-bearing car axles has been developed at the South Tacoma, Wash., shops of the Northern Pacific. Referring to the illustration it will be seen that this device consists of a small air cylinder with a hose and pipe connection from the shop air lines, the cylinder being applied in a steel yoke, the side bars of which are spaced far enough apart to fit over the end of the axle and engage the roller bearing collar by means of two screws, as indicated. The cylinder piston rod passes through a hole in the head

Device for removing shrink collars from roller bearing axles

of the yoke to which it is firmly secured by two large nuts and this construction holds the cylinder in line with the guide bars but permits the cylinder to move within the bars.

In operation, therefore, when the ends of the side bars are attached to the shrink collar and a small amount of air pressure is admitted to the cylinder, the piston rod is forced outward, taking up any slack and exerting a pull on the yoke. This tends to draw off the shrink collar.

The application of a small amount of heat uniformly around the roller bearing collar causes it to expand slightly, relieving the pressure on this shrink fit and allowing the collar to be quickly removed under operation of the air cylinder.

* * *

Santa Fe car inspection force looking over a train of military supplies at Wellington, Kan.—Car oilers are giving the journals and journal-box conditions special attention

# Enginehouse Transfer Tables

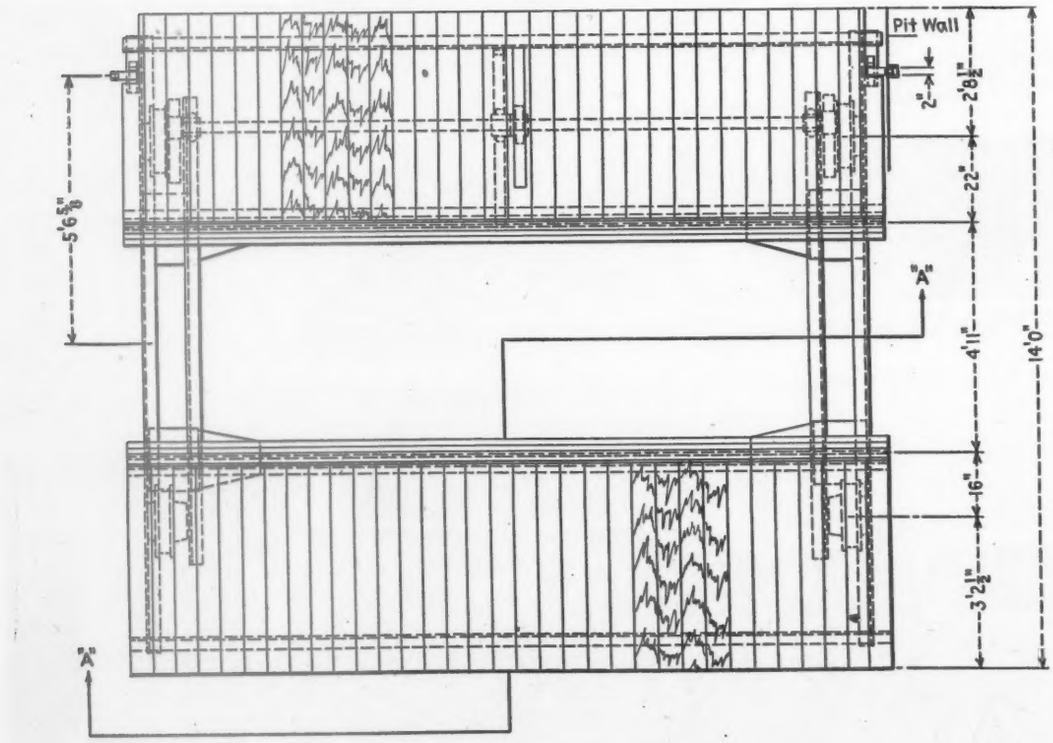
**Rock Island finds that tables serving two adjacent stalls in enginehouses are well suited to requirements of Diesel-electric locomotives**

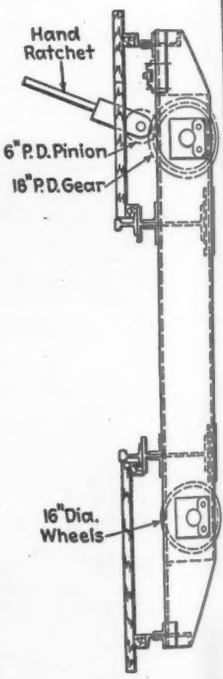
WHEN there is need to hurry, the Chicago, Rock Island & Pacific can change a truck on a Diesel-electric road locomotive in 45 minutes at any one of the seven points where it has installed enginehouse transfer tables. To make this time requires the use of more men than are normally used for this work, but it serves to indicate the effectiveness of the tables which have now been adopted as standard equipment for this service by the Rock Island.

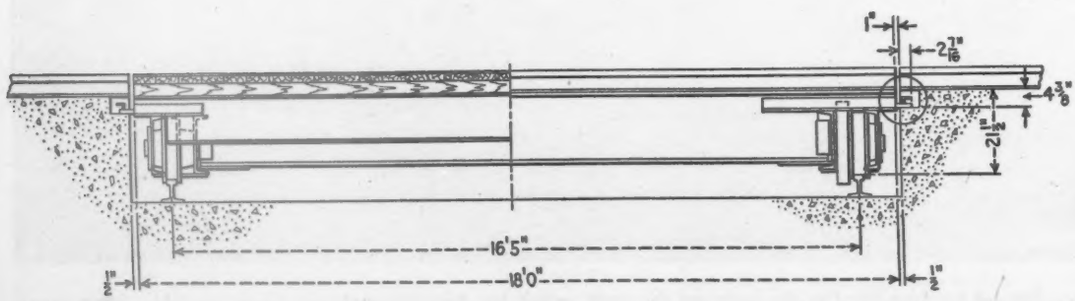
The table occupies two stalls in a section of the enginehouse devoted to running maintenance of Diesel-electric locomotives, both road locomotives and switchers. The table is 18 ft. long and 14 ft. wide and is designed to operate in a curved pit. It is equipped with four double-flanged cast-iron wheels fitted with roller bearings rotating on steel axles. The main frame consists of two heavy girders bolted to double channel trucks with heavy

The transfer table in service—The cab has been lifted by the jacks and the truck, which has been disconnected, is on the table, being drawn out by means of the overhead crane

Above: General view of the two stalls served by the table—Below: Plan and section of the table




Section "AA"

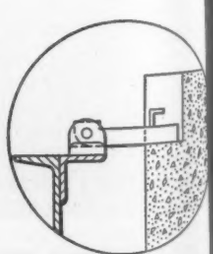


Table Lock

gussets to insure the rigid connection needed to hold the table square.

The top of the table is decked over only outside the rails with 1⅝-in. pine planking. A lever and ratchet arrangement is used on all but one of the tables for moving it on its rails and there is a locking device for holding the table in position while the trucks are being rolled on or off. The table is designed to withstand a live load of 165,000 lb. and to travel with a load of 57,000 lb.

In all but one of the installations there is an overhead crane which spans both tracks. The installation at Chicago, which is shown in the photographs, employs a crane which spans only one track. In this case also the table does not have the lever and ratchet mechanism and is moved by the crane with the aid of a cable and snatch block as shown. When the work must be done in a hurry, enough men are used to push the table from one track to the other.

The primary function of the crane is to lift trucks for the removal of wheels and to remove and apply traction motors. A 25-ton crane is required for six-wheel trucks and a 15-ton crane for four-wheel trucks.

When a truck is to be removed, the locomotive is brought in over the turntable into the enginehouse so that the truck to be removed rests on the transfer table. Motor leads and air hose are disconnected and center-pin lock removed, after which the end of the locomotive is raised about 18 in. by means of air-operated mechanical jacks under pads back of the truck. The step and skirting on one side are then removed and the truck moved out sidewise on the transfer table.

When the table is moved over to the adjacent track, the truck may be replaced with another or repaired and returned to the locomotive. About an hour's time is required to change out a motor from a truck and a wheel change requires about an hour and fifteen minutes.

Among the advantages of the transfer table are that its cost is low—only a shallow pit is required, a complete truck can be changed out, and no heavy overhead structure for supporting the locomotive is required. It is possible to employ the same procedure as described without the table, but this requires the removal of the pilot on *A* locomotive units, an operation which requires at least an hour for either removal or application.

The transfer tables were engineered and installed under the direction of the mechanical and engineering departments of the Chicago, Rock Island & Pacific, and were built by the Whiting Corporation, Harvey, Ill., and the Nichols Engineering Company, Chicago.

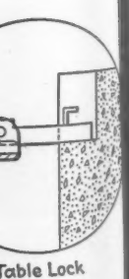


Table Lock

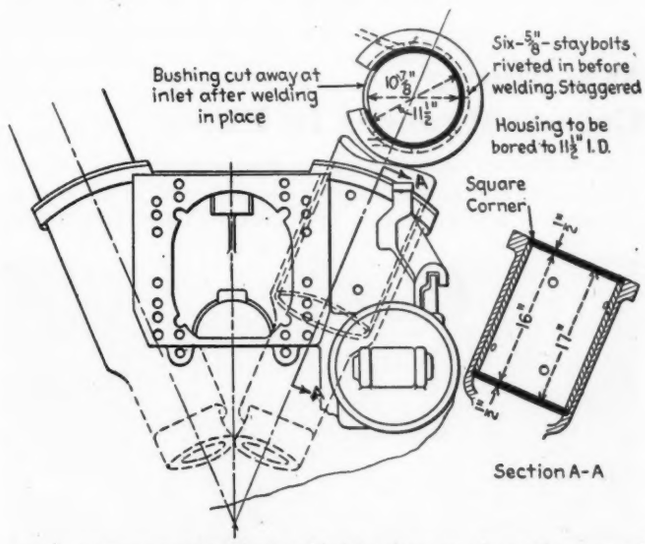
# Questions and Answers On Welding Practices

***(The material in this department is for the assistance of those who are interested in, or wish help on problems relating to welding practices as applied to locomotive and car maintenance. The department is open to any person who cares to submit problems for solution. All communications should bear the name and address of the writer, whose identity will not be disclosed when request is made to that effect.)***

## Bushings for Stoker Transfer Hoppers

Q.—What method do you recommend for bushing transfer hoppers in locomotive stokers?

A.—One railroad has found the method illustrated to be satisfactory. When the transfer hoppers are badly worn in the elevator screw bore, or worn through the side wall at any spot, they are rebored and bushed with steel bushings which are staybolted in place and welded around the edges. The oxyacetylene process is used on



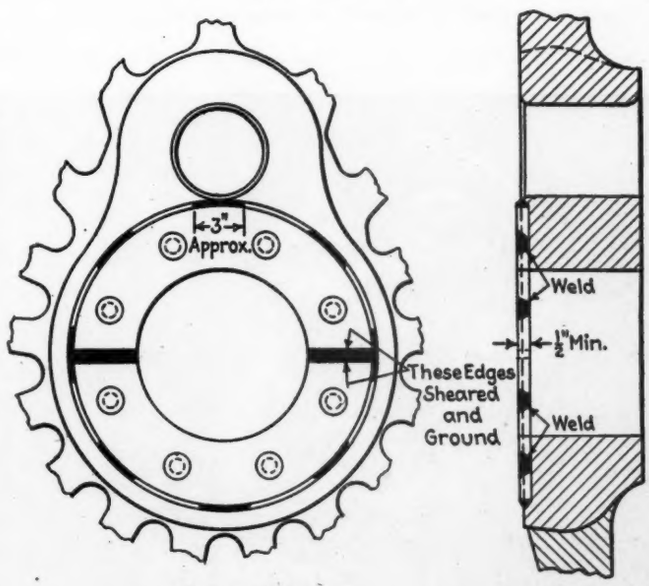

**Steel bushings, staybolted and welded in place, can be used to extend the life of stoker transfer hoppers**

this road and steel rods are employed for work on steel hoppers. Bushings for cast iron hoppers are welded with a bronze rod.

## Applying Wheel Hub Liners

Q.—What is the usual practice followed in welding hub liners to mounted wheels?

A.—The illustration shows the method employed by one railroad which has proved successful and may be regarded as typical. When lining hubs on mounted driving



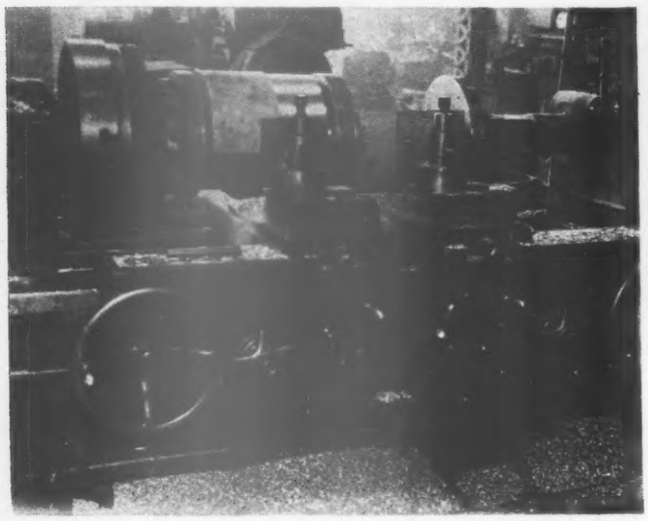

**Method of application of split liners to hubs on mounted driving wheels**

or truck wheels the practice is to split the liner ring which is then applied and welded to the hub in two sections. Three-inch skip welds are made on the circumference of the liner with additional welding to the hub

through drilled, countersunk holes. Steel liners are applied with steel rods and cast-iron liners with bronze. It is particularly important that the liners be clamped tight and flat against the hub before welding is started.

## Machining Crown Brasses in Pairs

Crown brasses are being machined in pairs in New York Central shops since the development of a special two-section arbor for use on engine lathes. The rough

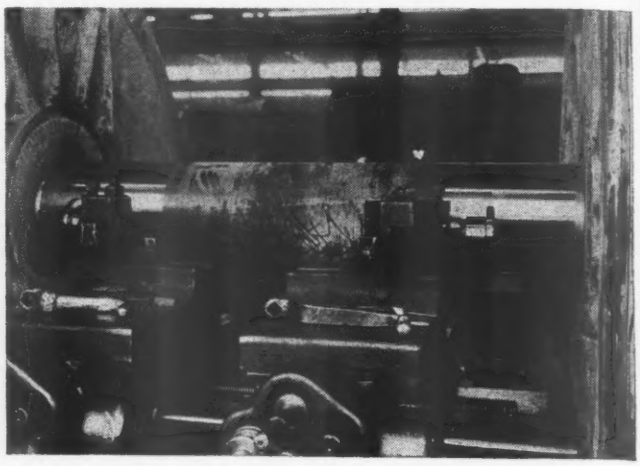


Crown brasses are machined in pairs by the use of this special arbor

castings are mounted opposite to each other in the two sections of the arbor to give balance. Two tool posts are provided in which high-speed tools are used. The rigidity of the arbor permits heavy cuts to be made. The machine shown was rebuilt and the special arbor was installed at the Collinwood shops at Cleveland, Ohio.

## Dry Rolling Journals and Crank Pins

Exceptionally good results are being secured with the dry rolling of locomotive main journals and crank pins at the Denver, Colo., shops of the Chicago, Burlington & Quincy. The finish secured is even more highly polished in appearance than with oil rolling and in fact



Dry-rolling a pair of locomotive main journals at the Denver shops of the C. B. & Q.

looks like a ground job. Moreover, the absence of oil in the rolling operation avoids any possibility of washing dust particles onto the journal in advance of the roller and the machine operator can see what the roller is doing more clearly than when the journal is flooded with oil.

The operation of dry rolling at the Denver shops is preceded by the usual practice of finishing journals with a $\frac{1}{32}$-in. feed using a $\frac{5}{8}$-in. high-speed steel tool bit having a flat cutting edge about $\frac{3}{8}$ in. long. This tool bit has the usual rounded corner to finish the small fillet at the driving-wheel hub plate.

The finishing tools are removed from the wheel lathe

* * *

How the petticoat pipe and smoke stack extension (left) and the spark arrester (right) are removed from a Santa Fe locomotive

tool posts and rollers inserted as shown in the illustration. Before starting to roll, however, the wheel lathe is started and the operator uses a rotary abrasive wheel, faced with a well-worn piece of the finest emery cloth available, to make a single pass once across the whole length of the journal to buff off the tops of the tool marks.

In dry rolling, the journal must be kept as nearly absolutely dry and clean as possible. No wiping of the journal, for example, with either waste or rags is permitted, but, after buffing, the journal is blown off with air and brushed lightly with a clean bench brush to remove any small particles of abrasive of dust which would otherwise become imbedded in the steel during the rolling operation.

The roller-bearing roller, a 7-in. diameter wheel, with a 5/8-in. face and a 3/8-in. radius on the leading edge, is set at the required angle as indicated by experience and checked for resetting by a marker dowel. Before starting to roll the journal, the roller itself is cleaned and polished lightly with a fine grade of worn emery cloth to remove any dust particles. The rolling operation is then performed on both journals at once in the usual manner, there being no appreciable difference in the time required for the operation.

In addition to dry rolling driving wheel journals, as illustrated, this same method is used for furnishing crank pins in the combination journal and crank-pin-turning machine, except that three-point rollers are used instead of a single roller. All rollers generally in use at this shop are made of alloy steel, S.A.E. Specification 52,100.

# Locomotive Boiler Questions and Answers

***By George M. Davies***

*(This department is for the help of those who desire assistance on locomotive boiler problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless special permission is given to do so. Our readers in the boiler shop are invited to submit their problems for solution.)*

## Application of Waist- And Guide-Yoke Sheet Angles

Q.—Should the angle flanges of waist-sheets and guide-yoke sheets be riveted directly to the shell of a boiler? We have considerable trouble in patching boiler shells which have cracked through these angle rivet holes and find it impractical to apply patches with the angles riveted to the patches.—F. D. M.

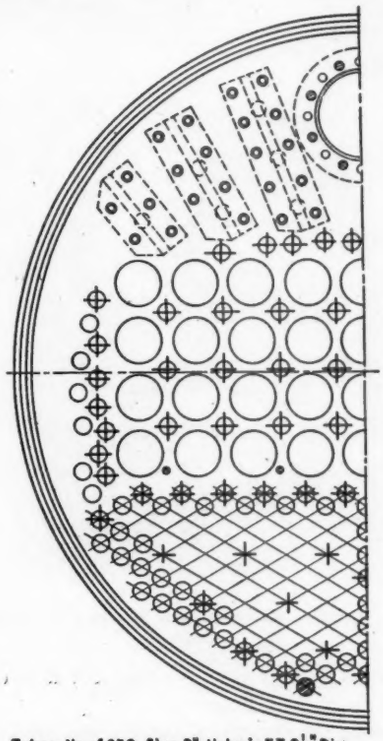
A.—With the exception of small boilers designed for low pressure, the present practice of applying waist-sheet angles is not to rivet the angles directly to the boiler shell. A bearing plate is riveted on the outside of the shell. The boiler may slide back and forth on the angle irons, supported by the waist sheets, with the bearing plate as a protection for the shell, or the angles can be riveted directly to the liner plate, but, not through both liner and shell.

The angle liners of the guide yoke sheet are similar in design to waist-sheet liners or bearing plates, with the exception that the angles must be riveted or made secure to the liners. In applying patches on the outside of the shell, due to cracks in the shell under the waist-sheet angles, the angles should not be riveted to the patch.

## Calculating Air Openings in Ashpans

Q.—How is the amount of air opening in a locomotive ashpan determined? Is it based on the amount of coal required to operate the locomotive?—F. B.

A.—The amount of air opening required in a locomotive ashpan is generally computed from the boiler tubes and flues. The most common practice is that the air openings in the ashpan should not be less than 100 per cent of the total tube and flue area, with the possible exception of narrow firebox locomotives used in switching service, where this percentage may be as low as 60 per cent of the total tube and flue area. To determine the required air opening of the locomotive the tube layout of which is illustrated, one must first obtain the net cross-sectional area of the flues with the superheater units in place as follows: Internal cross-sectional area of 5½-in. O.D. tube, No. 9 B.W.G. = 21.27 sq. in.; external cross-sectional area of 1½-in. O.D. superheater pipe = 1.77 sq. in. Each superheater unit is composed of four pipes; therefore, the total cross-sectional area will be 4 × 1.77 = 7.08 sq. in., and 21.27 — 7.08 = 14.09 sq. in., the net cross-section area of one flue.



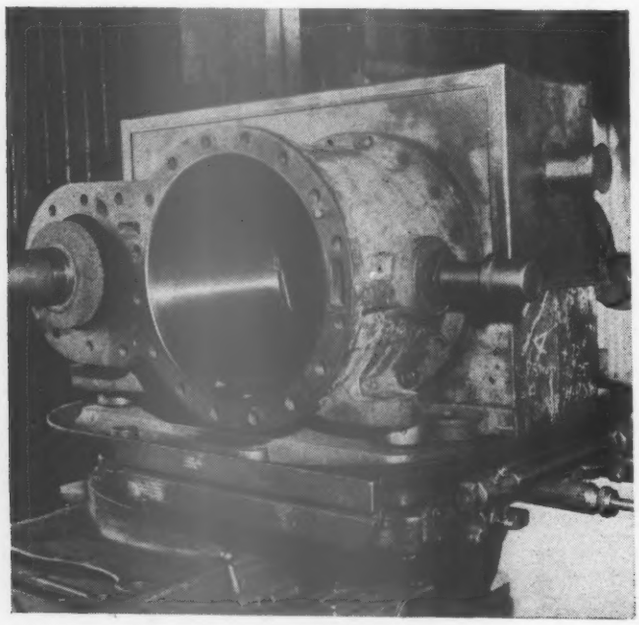

**A boiler having this flue and tube arrangement requires 1,083.54 sq. in. of openings in the ashpan**

We note that there are 230 2-in. O.D. tubes and 36 5½-in. O.D. flues shown in the layout illustrated. The internal cross-sectional area of one 2-in. O.D. tube, No. 12 B.W.G. = 2.49 sq. in., and 230 × 2.49 = 572.7 sq. in. Add 36 × 14.19 = 510.84 sq. in. for the superheater flues, including a total gas area through the boiler of 1,083.54 sq. in.

The boiler having a tube layout as shown would require 1,083.54 sq. in. of opening in the ashpan. On wide fireboxes the openings are provided on all sides directly under the firebox ring. On narrow fireboxes with deep pans the openings are provided in the sides of the ashpan itself.

## Grinding Jig for Air Compressor Cylinders

The grinding jig, illustrated, is being used at the Sacramento, Calif., shops of the Southern Pacific for grinding air-compressor cylinders. Used on a Micro internal grinder, this device consists of a hollow cast iron casting, made as shown in the drawing, with faces and bottom finished true and a sheet iron cover to which



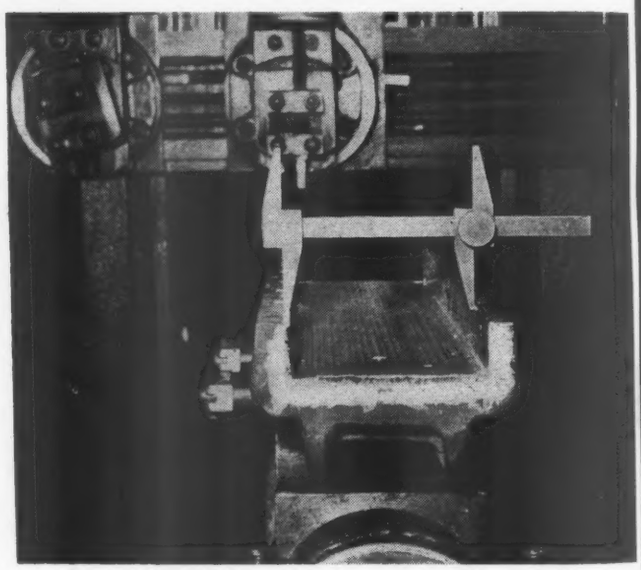
A jig used for grinding air-compressor cylinders on a Micro internal grinder

an air suction exhaust line is attached, acting as a trap for the dust from grinding.

This jig was developed primarily to insure alinement of all centerpieces and cylinders when changing cylinders from one compressor to another due to wear or breakage. The jig is located and secured to the grinder table with dowels and clamps, and can be reset to the correct position accurately whenever it has been removed from the machine for other work. Dowels are located in the face of the jig to correspond with the original dowel holes in the cylinders as received from the manufacturer. Trams are used to aline the table for both vertical and horizontal positions to bring cylinders to perfect centers. With the use of this jig, no laying out of centers or checking of old witness marks of former rebores is necessary.

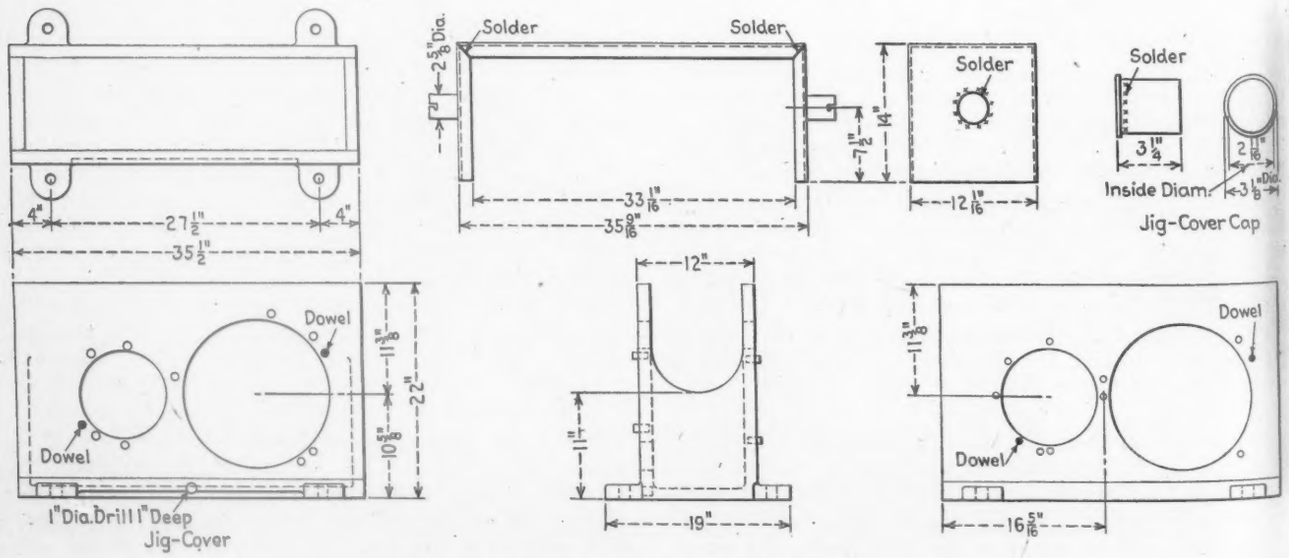
## Gage for Machining Crosshead Shoes

The crosshead shoe gage illustrated has one fixed and one sliding head designed for use as outside and inside calipers, the inside dimension including a small allowance for lateral play. This gage is first applied over the guide to obtain the exact width, the sliding head being secured in place with a thumb screw. The crosshead shoe is then machined to fit the other portion of the gage which makes allowance for the required lateral play. This type of



Gage for machining locomotive crosshead shoes

crosshead shoe gage is in use at the South Tacoma, Wash., locomotive shops of the Northern Pacific where it has been giving excellent service.




Details of the hollow cast-iron jig and sheet-iron dust cover

**Rock Island Relights**

# LaSalle Street Station

Interior of the relighted main waiting room showing a number of the new lighting units

THE Chicago, Rock Island & Pacific recently converted the lighting of the LaSalle Street Station at Chicago, Ill. The work consisted primarily of replacing the old ornamental heavy brass fixtures with new ones of simple and pleasing appearance, made almost entirely of glass.

**Substitution of old lighting fixtures for new greatly improves the appearance of the station, reduces power load, and salvages 4,800 lb. of brass**

Some of the 94 reclaimed brass fixtures—The soldier is holding one of the new units

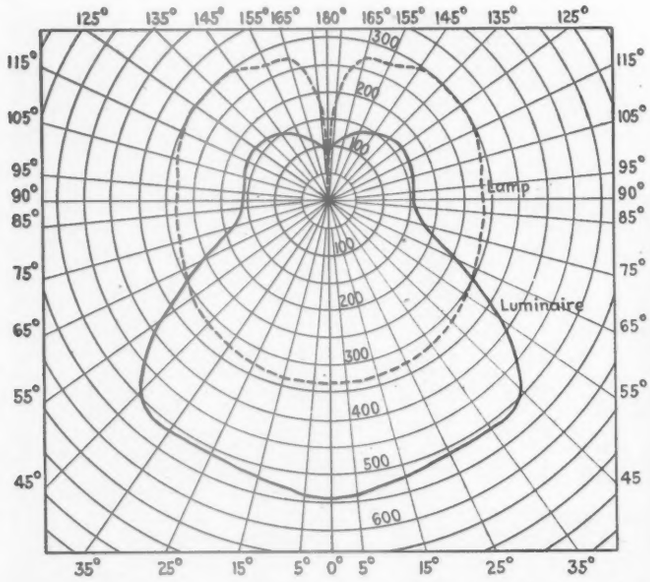
In the process of conversion 4,800 lb. of brass were salvaged. The lighting load on the station was reduced 8 kw., lighting intensities were considerably increased, and the appearance of the station greatly improved. The old lighting fixtures were open-top bowls, suspended on chains or brackets from the ceiling, each fitted with six 60-watt lamps. The absorption factor of the glass in the bowls when clean was 55 per cent and, since the bowls were open at the top, the accumulation of dirt soon reduced the efficiency to a value well below this amount. A few of the bowls were mounted flush in the low ceilings of corridors and passageways, but since these were not open at the top their over-all efficiency was probably somewhat less than that of the suspended fixtures.

The original pendant fixtures were supplemented by bare lamps arranged in a square around the center

of the waiting room ceiling. A part of these may be seen at the top of one of the illustrations.

## New Lighting Unit

The new lighting units, supplied by Anderson Lighting, Chicago, Ill., consist of white enamelled enclosing glass globes having a clear stippled bottom surface. The unit

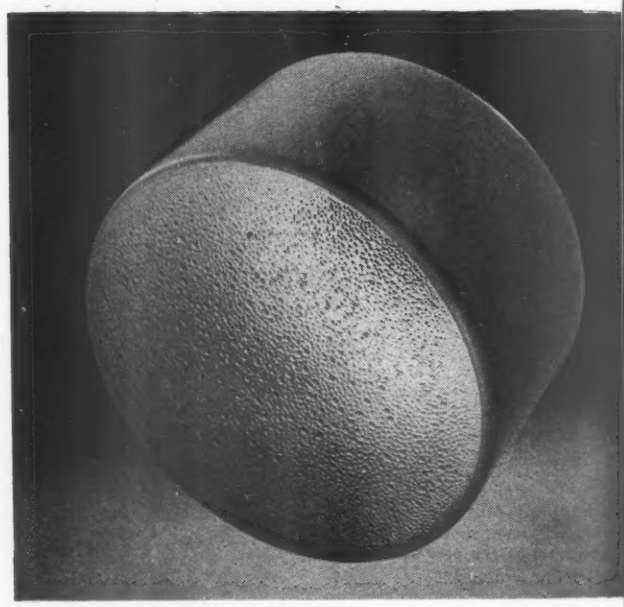



**Distribution curve for a No. 808 Anderson lighting unit, fitted with a 200-watt lamp**

known as No. 808 is made to fit 6-in. holders. Since it is totally-enclosed, the problem of keeping lamps and fixtures clean has been greatly simplified. Most of the units are fitted with 200-watt, 120-volt, 3,700-lumen PS30 inside frosted medium base lamps. The distribution curve shows light distribution for the bare lamp and for the lamp inside the luminaire. The lighting unit without its suspension chains weighs 6 lbs. 2 oz. Mos of the units are mounted on simple wall brackets, whil others are suspended directly from the ceiling. Th bare lamps formerly used in the ceiling (sometime referred to as "carnival" lights) have been replaced b six of the Anderson units, each equipped with 300-wat lamps.

## Salvage

Removal of the old units was started almost a yea ago. They included 94 ornate brass fixtures. Includ ing brackets and chains they represented 4,800 lb. o brass, the scrap value of which was sufficient to pa for a considerable part of the cost of the new units.



**One of the No. 808 enclosing glass globes showing the clear stipple lower surface used to effect good distribution with low absorptio**

**Interior of the statio before relighting—Som of the old suspende bowl type reflectors ma be seen at the rear— part of the square of t bare lamps is shown the top**

**Service Interruptions Reduced By**

# Testing Electrical Insulation

**By Graham Lee Moses†**

**Suggestions for using the various available methods to determine the condition of insulation correctly and accurately**

INSULATION is a "necessary evil" in electrical apparatus. It occupies useful space which the designer would prefer to utilize for conductors or magnetic circuit; however, it is an essential part of every electrical machine. Furthermore, insulation is the most vulnerable part of a machine as it is subject to mechanical damage, thermal aging,

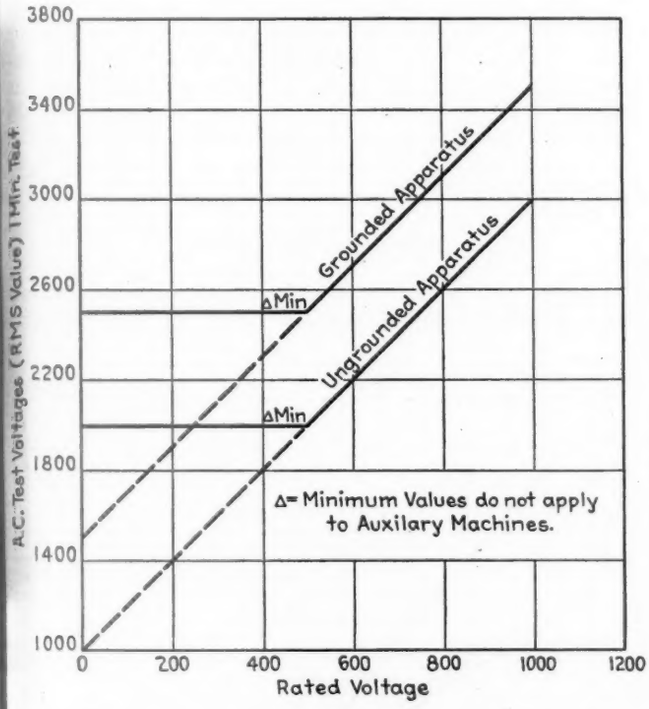



**Fig. 1—High potential tests for railway motors and other rotating machinery for rail cars and locomotives of rated voltages up to 1,000, ASA. C35, AIEE No. 11**

and the deteriorating influence of moisture, oils and corrosive atmosphere. It is desirable to maintain the quality of insulation at a high level to insure satisfactory operation. A well thought out testing program with adequate test equipment and trained personnel will go far in minimizing service interruptions from insulation failures as incipient faults can be weeded out during the periodic testing. Defective insulation should fail under test in the shop rather than in service.

## Purpose and Adequacy of Insulation

The purpose of insulation in electrical apparatus is to separate circuits and parts of different potential. This is accomplished by (1) providing suitable spacing or striking distance through air; (2) separating by sufficient creepage distance across an insulating surface or through porous insulation; and (3) enclosing one element of the circuit within an insulating film or separating by a solid dielectric barrier having suitable dielectric strength.

† Insulation development engineer, transportation and generator engineering department, Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.

On most electrical apparatus, all three methods of insulating are employed as it is practically impossible to completely enclose all of any circuit component in a solid dielectric sheath. It is highly desirable to use this third method because of the tremendous increase in breakdown voltage obtainable in a given space in comparison with the other two.

The adequacy of insulation for a given service is demonstrated by high potential tests. Since the nature and purpose of such tests are varied, a brief review of the

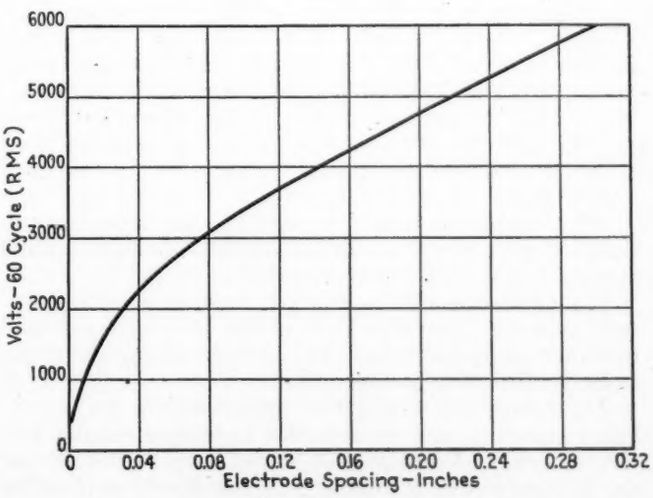



**Fig. 2—Approximate creepage flashover characteristics of clean, dry insulation**

classes and purposes is essential to any discussion. It is generally agreed that laboratory or factory tests cannot simulate conditions of service or completely prove that insulation is suitable for operation in a specific service. In this connection, it must be recognized that insulation has many other important properties in addition to dielectric strength, and that selection on the basis of initial dielectric breakdown strength alone does not necessarily produce the best design. The physical characteristics of the insulation and its thermal endurance determine how well its initial dielectric strength is maintained throughout its life, as the ability of the insulation to withstand physical abuse is of utmost importance.

## High Potential Tests

High potential tests are most generally made on insulation for the following reasons:

(1) Tests to destruction are made on typical material specimens to determine the general characteristics.

(2) Proof tests are made on insulation during manufacture to detect flaws. Such tests are frequently made during the fabrication of the insulation and manufacture of the coils as well as winding of the apparatus. Tests of this sort are primarily a matter of manufacturing economy to detect mechanical damage before repairs or replacements are too costly.

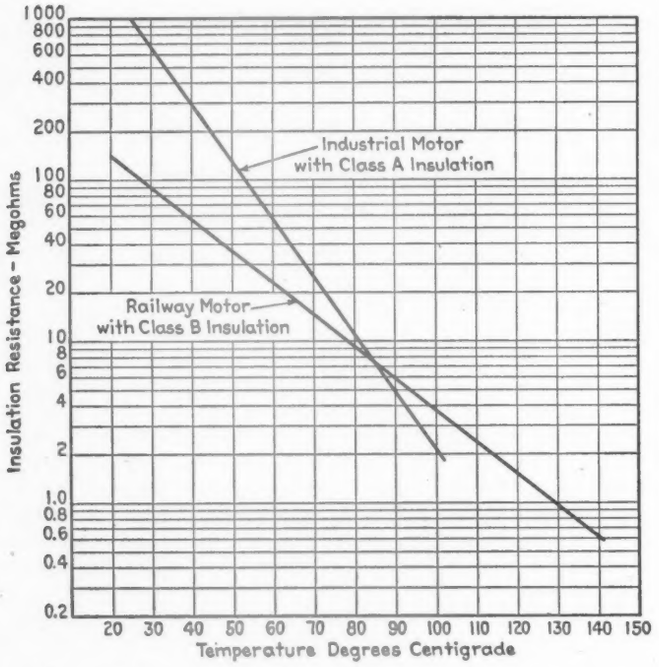



**Fig. 3—Curves showing effect of temperatures on typical railway and industrial motors**

(3) Acceptance tests are made on new apparatus to demonstrate that the insulation strength of the completed apparatus is above a certain specified level.

(4) Operation check tests are made in service to insure that the apparatus is in usable condition and that there are no incipient flaws in the insulation which might make it unsuitable for operation.

The values for testing new apparatus are well established standards and are intended to include suitable factors of safety, determined by experience, to insure that the insulation will withstand (a) continuous application of rated voltage throughout the expected life of the machine; and (b) occasional over-potentials encountered in normal operation due to switching, surges, etc.

Usually, standard acceptance tests are of one minute duration and are based on the formula:

$E_t = M \times E + C$

$E$ = Rated voltage of the apparatus
$C$ = Specified constant voltage
$M$ = Multiplier for the particular application

On railway apparatus A.I.E.E. Standards No. 11 specifies that $M = 2$ and that for machines operating on grounded circuits, $C = 1{,}500$, with $E_t$ minimum = 2,500 volts, while for machines operating on ungrounded circuits, $C = 1{,}000$ with $E_t$ minimum = 2,000 volts. The minimums do not apply to auxiliary apparatus. These relations are shown graphically in Fig. 1.

Similar high potential tests (operation check tests) in service are not standardized and vary widely at the discretion of the operating organization. In general, it may be said that such a test should not be less than 50 per cent of the standard test value for a new machine and preferably approximately 75 per cent of that value. An important factor sometimes overlooked is that insulation thickness varies on different designs for the same voltage. In some instances operation check tests are used which will not detect a complete puncture in the ground insulation when it is dry. Fig. 2 shows the approximate creepage flashover voltages for small creepage distances. Test voltages should always be in excess of these values for the insulation wall thickness being tested.

Before applying high potential tests to apparatus in service (and in the factory) it is desirable to apply some non-destructive test. Frequently such a test will indicate the necessity of preventive maintenance (such as drying or cleaning) in time to avoid failure which would have occurred had the hi-pot test been applied directly. Insulation resistance measurements are commonly used for this purpose.

## Insulation Resistance

The insulation resistance of a machine between windings and the frame is not a measure of the dielectric strength of the insulation. However, when properly interpreted, it may afford a useful indication of whether or not the machine is in suitable condition for operation or for the application of the dielectric or other tests. Periodic insulation resistance tests of machines in service are recommended as a means of detecting whether operating conditions have caused a change in

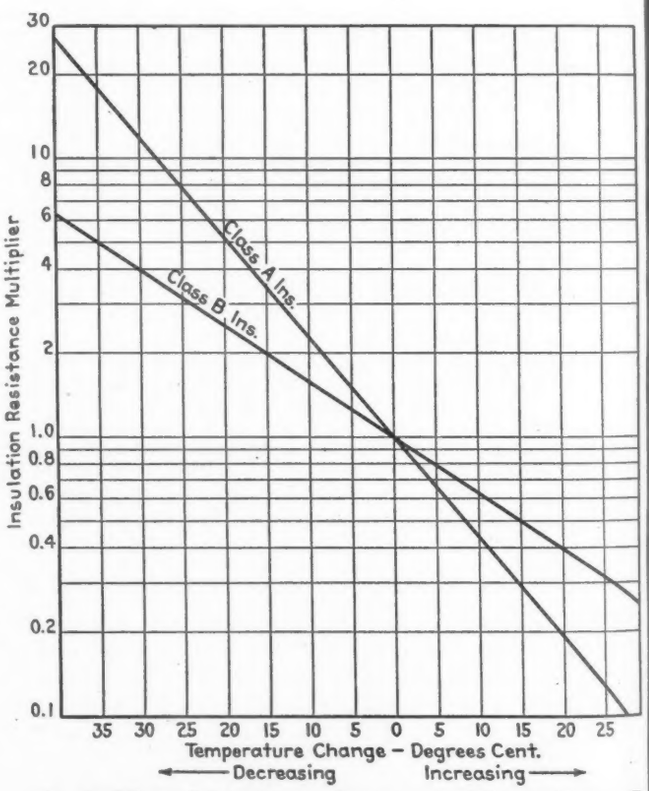
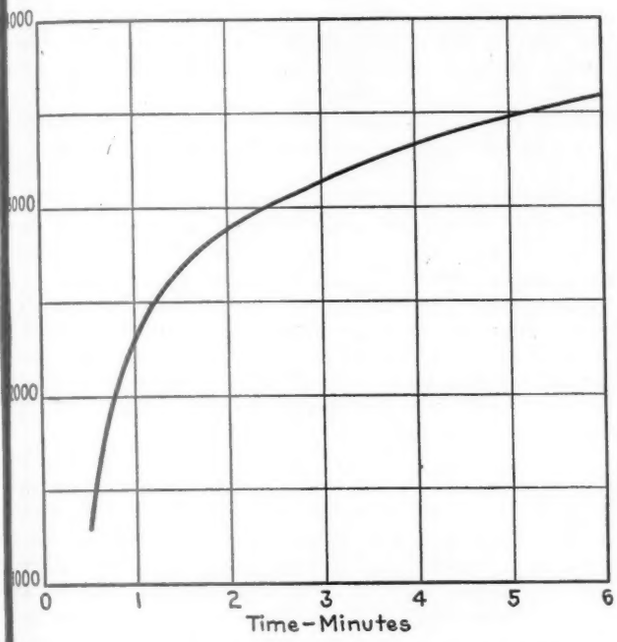



**Fig. 4—Effect of temperature change on insulation resistance—To estimate insulation resistance multiply observed value by multiplier for temperature increase or decrease**

e condition of the insulation. Such changes may re-
lt in reduced dielectric strength or may be indicative
reduced creepage insulation resistance from surface
posits of dirt, moisture, or even oil, etc., resulting
om operation.

A high value of insulation resistance is usually indica-
e of clean and well dried insulation but is not by
elf proof that the insulation does not have mechanical
ults of a type which may not appreciably affect the
easured value of insulation resistance, yet which may
use the insulation to break down upon the applica-
n of voltage.

Insulation resistance varies greatly with changes in
mperature even while moisture conditions are stable.
n addition the drying effect of high temperatures




ig. 5—Insulation resistance vs. time for armatures of railway motors tested at 500 volts d.c.

ust be considered.) Fig. 3 illustrates the effect of
mperature variation on an industrial motor with Class
insulation and a railway motor with Class B insu-
ion. The temperature effect shown in this curve is
pical of clean dry insulation of this general type.
he following approximate formula is useful in esti-
ating the effect of temperature changes where the
mperature change is not too great.

$R = rC^n$

Where

$R$ = Insulation resistance at T°C.

$C$ = Constant

.44 for Class $A$ insulation* and .63 for Class $B$ insulation*
(as used on industrial and railway motors)

$n$ = Exponent = $\frac{T-t}{10}$

A convenient method of translating insulation re-
stance observed at one temperature to the equivalent
lue at some other temperature is shown in Fig. 4.

Time of uninterrupted voltage application has a con-
derable effect on the observed insulation resistance
lue as illustrated in Fig. 5. Different materials and
nditions of insulation have their own characteristic

* These "constants" are for these particular types of insulation when
n and dry. They change slightly as the insulation becomes dirty or
es up moisture. This change with temperature is so great that consid-
ion must always be given to temperature differences when comparing
ulation resistance values.

curve slopes. Insulation resistance continues to increase as the voltage is applied uninterruptedly. It may increase for many minutes, reaching a value several times the one minute reading. As a general statement it may be said, the longer it takes the insulation resistance to reach stability, the higher the quality of insulation. Wet or dirty insulation will quickly reach a state of equilibrium.

The observed insulation resistance value will be affected by the voltage applied to the insulation under test. Usually the observed value will decrease somewhat

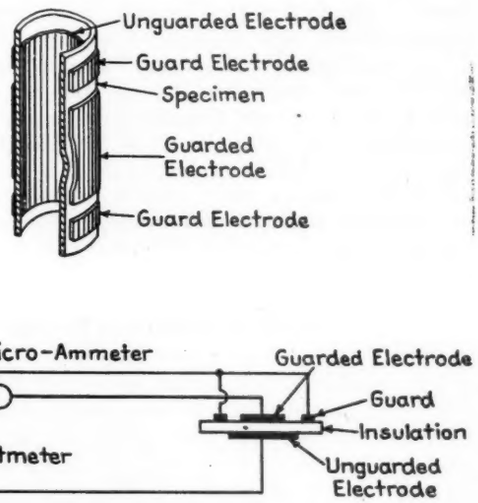



Fig. 6—(Above)—Conventional guard arrangement—(Below)— Simplified guard circuit for insulation resistance testing

with an increase in applied voltage. It is therefore important to use a standard voltage for comparative data. Usually, 500 volts d.c. is used for such observations.

Values of insulation resistance are markedly affected by residual charges retained in the winding. For this reason windings should be discharged by grounding for several minutes before observing insulation resistance.

Relative moisture content of the insulation can be detected by insulation resistance values. This condition is indicated by (a) lowered insulation resistance; (b) insulation resistance value quickly becoming stable after application of voltage; and (c) a reduction in the ratio of cold to hot values. High moisture content in the insulation is likely to produce failure of the main ground insulation resulting in complete shut down of the equipment unless it is dried out and perhaps retreated. Use of guard circuits will have little effect on the observed insulation resistance of wet insulation.

Surface dirt and creepage across slightly conducting surfaces can be detected by insulation resistance measurements. This condition can be detected in three ways, namely, (a) reduction in observed insulation resistance; (b) shorter time for insulation resistance value to reach a steady state; and (c) change in the ratio of cold to hot insulation resistance values. By using guard circuits on the creepage surfaces, considerably higher insulation resistance values will be observed on dirty insulation. Such conditions of dirt may cause surface flashover without serious damage to the basic insulation. Cleaning the dirty creepage surfaces may prevent damage and service interruption.

A guard circuit for insulation resistance testing is shown schematically in the diagram. It consists of a simple insulation resistance testing circuit, in this case including a voltage source, a voltmeter, a micro-ammeter, insulation specimen and electrodes. One electrode is

completely surrounded by a guard ring. The function of the guard ring is to collect surface leakage currents and by-pass the micro-ammeter. This combination will give the volume resistance of the specimen as the guard by-passes surface leakage currents. By the use of such guard circuits, which are somewhat more complicated on direct reading insulation resistance meters, it is possible to separate surface leakage currents from straight conducted currents.

Insulation resistance data may be obtained with reasonable satisfaction by the use of a high resistance voltmeter, a micro-ammeter or a direct reading resistance meter. The latter type is preferable as it provides an uninterrupted high voltage of controlled value and is direct reading. The "Megger" type of meter has long met this need and motor driven Meggers are now available which eliminate the chore of cranking as well as providing closer speed control for the generator. The electronic type of "megohm bridge" is particularly well suited to measure very high insulation resistance and to maintain a controlled voltage uninterruptedly for taking dielectric absorption data.

## High Frequency Testing

The insulation testing discussed thus far covers the ground insulation which has the maximum potential stress. However, the insulation between turns, coils, layers or phases is equally important to satisfactory operation. Such insulation is difficult to test except during manufacture unless special equipment is used. This class of insulation can be tested by applying a high frequence voltage (usually several thousand cycles) across the winding terminals. High frequency is used to permit application of a high potential to the winding circuit and still keep the current through the winding to a low value by setting up a high impedance. In this manner the total voltage applied to the winding is distributed in a fairly uniform manner across the turns between terminals. This results in a voltage test between adjacent turns or coils of several times normal voltage. Such tests have been proven to be satisfactory for weeding out incipient failures before they can cause service interruption. There are three basic types of apparatus which may be used for high potential testing of turn insulation, as follows:

(1) An early type of high frequency test outfit produces an oscillatory high frequency discharge through a spark gap. This employs a high voltage transformer charging a condenser, which discharges through a rotating disc air gap. The oscillatory discharge thus produced is damped high frequency at the natural resonant frequency of the circuit. The condenser is charged on each half cycle and a series of these oscillatory discharges takes place in each half cycle of the transformer power supply. The voltage of the high frequency test is controlled by varying the air gap between the rotary discs. A wave meter is used for detecting insulation faults. Any short circuit in the winding changes the inductance and thereby the natural resonant frequency of the circuit making this device very sensitive. For proper and consistent results this device requires technically trained personnel to operate and adjust the test apparatus.

(2) More recently electronic type oscillators have been employed as a source of high frequency voltage for turn insulation and detection of short circuits in windings. Testers of this type supply a variable voltage at a controlled frequency. Usually the high frequency voltage is measured by means of a cathode-ray oscillograph. Defects are detected by distortion of wave shape and by changes in amplitude of the wave, wh changes in circuit constants (due to faults) are su cient to throw the circuit out of resonance. This t equipment provides a satisfactory source of high f quency voltage for testing turn insulation and can operated by testers with only a little training. Ho ever, on some apparatus, it is not as sensitive as oth types and frequently certain kinds of faults are ha to detect. It is particularly useful in testing a lar number of similar units on a production line basis.

(3) A recently developed insulation test equipme is suitable for testing turn insulation, similar to hi frequency tests, by applying surge voltages alternat in reverse directions through the winding. It also c be used for testing ground insulation. The equipme consists of a surge generator which is alternately co nected to two winding terminals every other half cyc (of the 60-cycle power supply) by a synchronous doubl throw, two-pole switch. Thus a surge voltage is prop gated through the winding, first in one direction a then in the other. Their effect is observed on a cathod ray oscillograph so that two parts of the winding ( two identical coils) can be compared. When the tw windings are symmetrical, the images in the cathod ray oscillograph are identical and appear as a sing image. Any fault, such as a shorted turn, affects th two waves differently and produces two images on th oscillograph. The shape of the waves can be interpret (from experience) as indicating the nature of the fau It should be recognized that this device gives com parative information regarding two parts of a windi or two coils while applying a surge voltage which propagated through the winding.

To date high frequency testing has largely been co fined to manufacturers, but the trend toward increase emphasis on electronic devices should awaken intere in this very useful tool. It should be suitable for u in larger repair shops with trained personnel where high insulation level is being maintained. Normal tes ing technique with high frequency test sets is to app the same test voltage across the winding that is appli between the winding and ground as a high potenti test.

The importance of insulation and the fact that man service interruptions are attributed to insulation failu are believed to justify periodic testing. To be of re value such a test program should be coordinated wi the normal inspection and maintenance program. Th precise testing procedure and test equipment necessa should be discussed with the manufacturer and the setu made with careful consideration of the requirements the service and the importance of avoiding service in terruptions.

* * *

**Westinghouse foreman gives instructions on insulation resistance measurement**

*(Turn to next left-hand page)*

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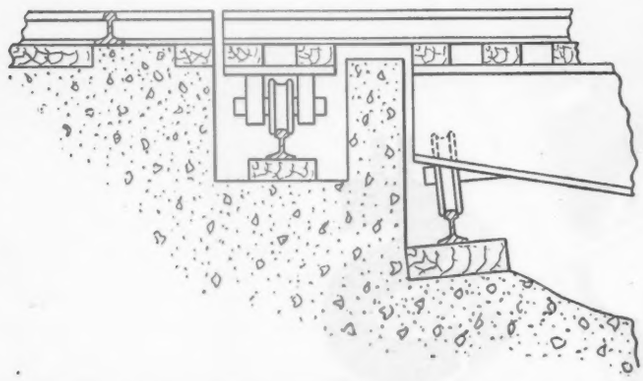
# CONSULTING DEPARTMENT

## Turntable Signals

*There is always the danger that a locomotive may be moved onto or off a turntable when the rails are not properly lined up. Can you suggest a system of signals or other means which will tell the hostler when the tracks are properly aligned?*

### Locomotive Trap

There are on record instances of hostlers running locomotives into turntable pits, but this type of accident is comparatively unimportant when compared to those caused by "runaway" locomotives. No system of signal lights will control a locomotive of this type; I suggest turntables be constructed in such a manner that any lo motive will be stopped should it happen to pass a cert point when the turntable rails are not properly align



**The retaining wall between the catch pit and the turntable pit should be reinforced to insure its stopping the locomotive.**

As shown in the accompanying drawing, a small ca pit in the form of a circular ditch is provided betwe the point where the stationary rails end and where t turntable pit begins. In order to bridge this gap betwe the stationary rails and the turntable, the rails fastened the turntable are extended beyond the end of the ta and their free ends are carried by a small pony truck signed to ride on a rail located in the circular ditch. T turntable side of the circular ditch would have to heavily reinforced so as to be strong enough to stop a locomotive which happens to have a pair of its whe drop into the ditch.

If the suggested type of construction were used, I quite certain that a locomotive actually getting into t main turntable pit would be a thing of the past.

FORD C. PETHICK

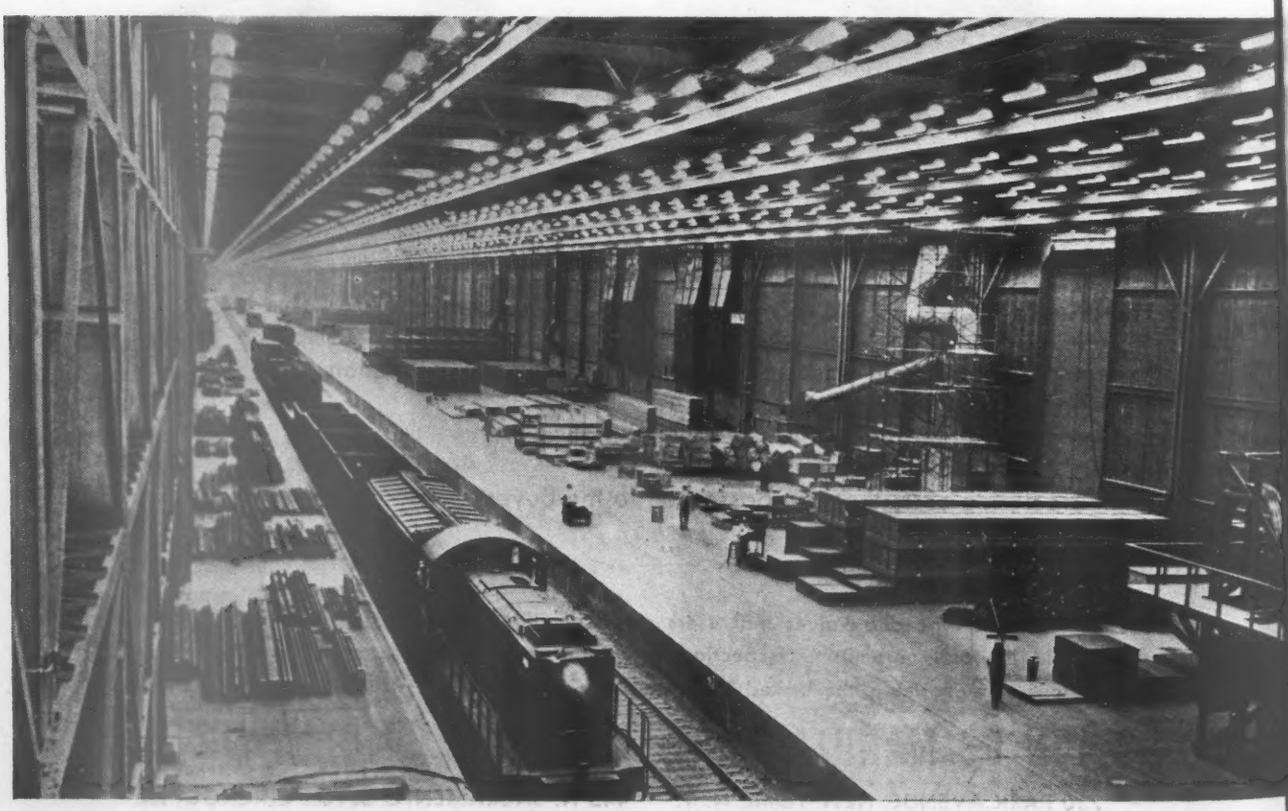
* * *

**Can you answer the following question? Answers should be addressed: Electrical Editor, *Railway Mechanical Engineer*, 30 Church Street, N. Y.**

●

*In one drafting room fluorescent type lighting fixtures are installed directly over each drafting table as individual lighting units. In another drafting room the the fluorescent type fixtures are placed high in the ceiling so as to give excellent general illumination. What are the advantages and disadvantages of both arrangements?*

●

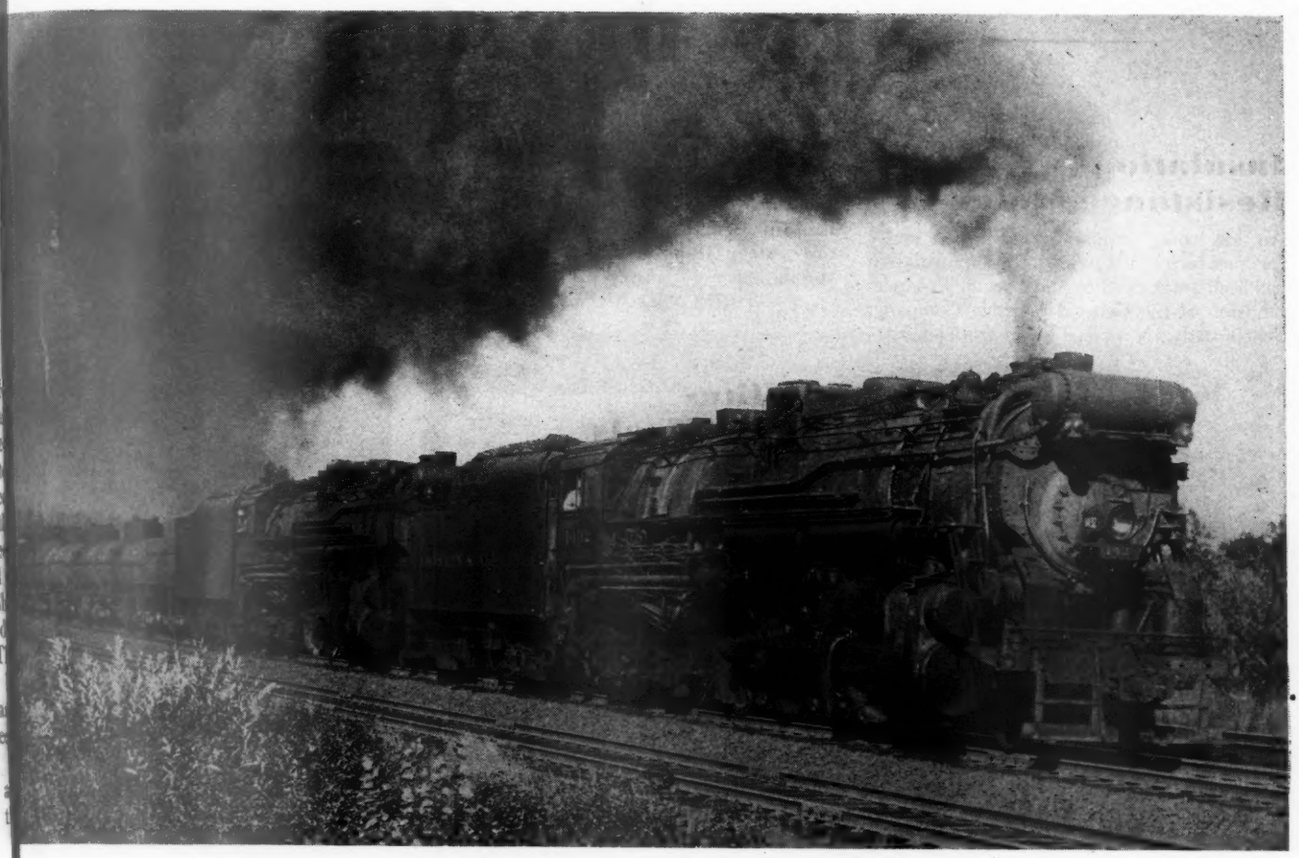


**Units are cleaned and relamped from suspended catwalks paralleling the rows of units—There are 39 miles of such catwalks in the plant.**

**Railroad bay of the Bell bomber plant at Marietta, Ga.—The area is lighted entirely by two-lamp Sylvania fluorescent fixtures each 5 long, mounted end to end**



*(Turn to next left-hand page)*



# *Performance* is the PAY-OFF!

**No railroad can wring more miles out of a locomotive than its builder has packed into it. Lima-built locomotives give you the superior performance, the extra stamina and greater mileage that flow directly from Lima's insistence upon the highest standards of design, workmanship, and materials.**

**The economic superiority of the steam locomotive has never been better demonstrated than by the remarkable record it has set in its speeding of the heaviest wartime traffic. In the current performance of Lima-built Modern Steam Locomotives will be found countless examples of what can actually be expected from steam power at its best.**

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# NEW DEVICES

## Insulation Resistance Meter

An electronic insulation resistance meter for measuring the resistance of insulation has been announced by the Special Products Division of the General Electric Company, Schenectady, N. Y. The instrument consists of a conventional electronic rectifier, a Thyrite bridge circuit, and an electronic-tube voltmeter. It is available in two types. One type has a scale calibrated from 1 to 50 megohms and measures resistance at 500 volts d.c. The other type has a 0 to 20,000 megohm total range and measures resistance over four different resistance intervals: 0-5 megohms at 0-250 volts d.c. and 5-200, 50-2,000 and 500-20,000 megohms at 500 volts d.c. Any range may be quickly selected by a panel-mounted rotary switch.

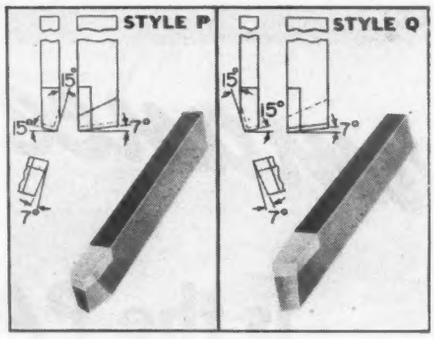
G-E insulation resistance meter

## Aluminum Bronze Coated Electrodes

The Air Reduction Sales Company, New York, has developed an aluminum-bronze-coated electrode, AIRCO No. 100, described as a high-tensile bronze shielded-arc electrode which can also be used as a filler rod in carbon arc welding. This electrode has a universal application in welding most bronzes, malleable or cast iron and steel, and is said to produce welding deposits of great strength and high ductility with resistance to corrosion. The electrode also has other specific applications for which it is especially suited, such as welding manganese bronze conforming to Federal Specifications QQ-B-726b, or Navy Specifications 49-B-3e, where unusual strength, ductility and corrosion resistance are strict requirements. The AIRCO No. 100 can also be used for welding dissimilar metals, such as cast iron to brass, steel to malleable iron, or any two metals weldable with aluminum-bronze. Standard sizes of the electrode are from ⅛-in. to 3/16-in. in 14-in. lengths, and ¼-in. in 18-in. lengths, while sizes from 5/16-in to ½-in. in 18-in. lengths are available on special order.

## Stellite-Tipped Tools

Two styles of tipped tools designed for the machining of steel have been introduced recently by the Haynes Stellite Company, a unit of Union Carbide and Carbon Corp., Kokomo, Ind. The new tools consist of a cutting tip of Stellite cobalt-base alloy brazed or butt-welded to a tough steel shank with the proper clearance and lead angles ground for turning steel. They are recommended for applications employing tools that have a large cross section or tools that are bent or offset, or for tool holders that make the use of solid tool bits impracticable. Used mainly for turning, boring and facing operations these tools can also be used for various types of forming and grooving operations.

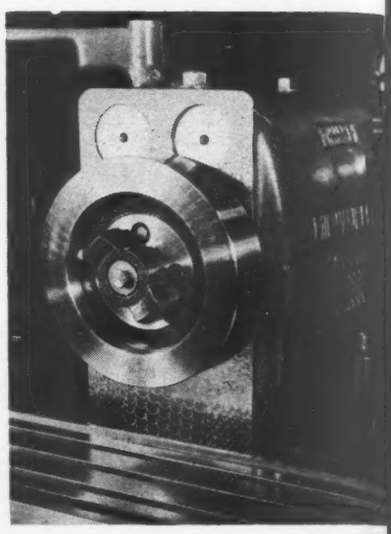



Tools recommended for use on steel where the tools must have a large cross section

Style P is a right-hand tool; style Q a left-hand tool. Both are ground with a 15-deg. end-cutting-edge angle, a 15-deg. side-cutting-edge angle, a 7-deg. end-relief angle, and a 7-deg. side-relief angle. They are furnished with flat tops so that users can grind their own side-rake angle. Five sizes of each tool are carried in stock by the company.

## Flywheel Arbors

The increased use of carbide-tipped and fly cutters for milling operations has resulted in the development of a fly wheel to be incorporated in the machine drive. The coarse-bladed nature of these cutters resulted in a "bumping" action of the tools which is said to be damped out by the use of flywheels according to the manufacturers, Weddell Tools, Inc., Roche N. Y.



Flywheel arbor intended for use with fly c ters or carbide milling tools

Flywheel arbors are used to replace standard end-mill arbors and are mou on the machine spindles. This combina flywheel and arbor has a nose which replica of the nose end of the shell end- arbor, onto which the milling or fly cu is fastened and from which it is dri The flywheel arbor is made with a coun bored back or locating means to fit milling machine or horizontal boring m The arbor nose is made in standard s from ¾ in. to 2½ in. in diameter.

For the use of cutters which fit dire on the spindle, a flywheel spindle-n adapter has been developed. The back this is counterbored or adapted to fit machine-spindle nose, permitting mounting of the standard cutter. Simi adapters are available permitting the of taper shank cutters. It is said that use of these arbors or adapters allow lighter-bodied, less-expensive and m easily handled cutter to be used. Stand sizes are stocked and special shapes can furnished for particular working set-up

## Centrifugal Pump

The Wayne Pump Company, Fort Way Ind., is introducing a centrifugal pump handling gasoline or fuel oils which is s to differ from other similar units in tha is self-priming and air-eliminating in own action, and can be used to pump fr underground storage tanks or to unl tank cars from the top. The pump is adapted to operation with flooded suct where storage tanks are located al ground or where tank cars are unloa from underneath.

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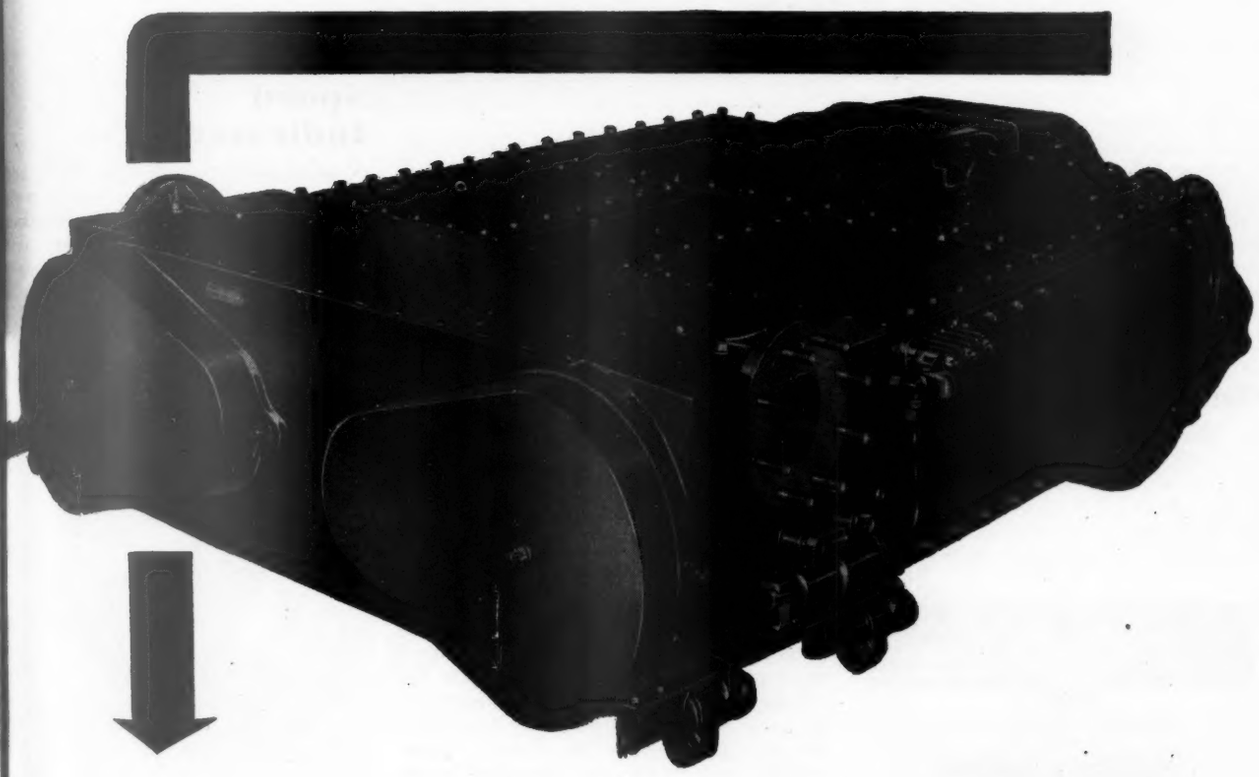
# *Full Initial*

# STARTING EFFORT



## *s a feature of the NEW Type 'E' Booster**

THE new Type "E" Booster will get heavy trains started easily. For a special starting feature enables the new Type "E" Booster to develop its maximum starting effort right at the time it is most needed.

The new Type "E" Booster also delivers higher draw bar pull at speed. This is due to a new cylinder design with integral inlet and exhaust manifolds, the large steam and exhaust passages of which give maximum inlet pressures and minimum exhaust pressures. Dynamic balancing, a roller bearing crank shaft, and new design inlet and exhaust steam ball joints also contribute to the smooth operation and higher operating speeds of the new Type "E" Booster.

*Trade Mark Reg. U. S. Pat. Off.

**FRANKLIN RAILWAY SUPPLY COMPANY, INC.**

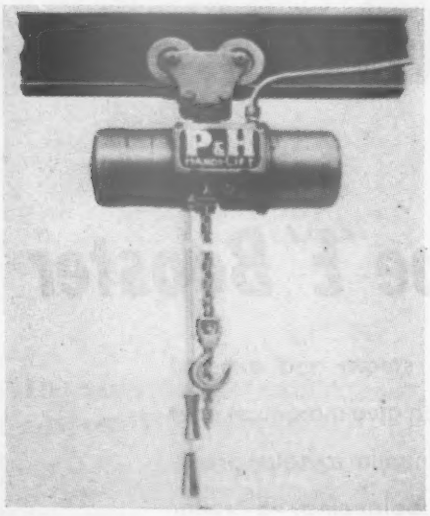
NEW YORK • CHICAGO

In Canada: FRANKLIN RAILWAY SUPPLY COMPANY, LIMITED, MONTREAL

The unit incorporates simple hydraulic jets in conjunction with a centrifugal impeller. The jets are fed by a small portion of the delivery from the large impeller and they in turn create vacuum for priming the pump and for eliminating vapor and air from the suction line. Because the pump automatically separates air from the liquid, it can be used with meters without the necessity of adding air separators. Another important feature of the pump is the fact that the centrifugal characteristics permit the use of a large unit with multiple outlets. Regardless of the number of outlets, however, no by-pass valve is required so that there is no shock, hydraulic hammer, or excessive pressure when the outlets are closed. Since the pump has only one impeller, agitation of the liquid and foaming are minimized, which are of importance in fueling Diesel locomotives. Pumps of 15, 25, 100, 200 and 300 gal. per min. are available and these units are equipped with ⅛-, ¾-, 3-, 5- and 7½-hp. motors. A complete line of positive displacement meters is also available.

## Electric Chain Hoist

The Harnischfeger Corporation, Milwaukee 14, Wis., has introduced a small Handi-Lift electric chain hoist for users having need for this type of equipment. The utility of the unit is increased because it can be converted to bolt, hook or trolley mounting with the changeover requiring the loosening of one bolt only. In addition, when used in trolley service, it can be suspended either parallel or crosswise to the beam. It is made with a fully enclosed construction to permit use under any weather, dust, moisture or acid conditions.

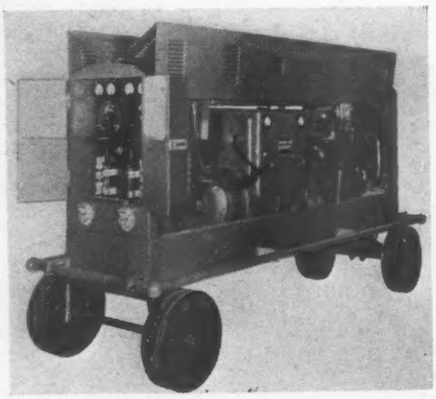



A 500-lb. capacity electric chain hoist which is readily mounted in a variety of ways

The unit is rated at 500 lb, capacity with the chain tested to 1,800 lb. Operation is by a pull-cord actuating a toggle-lever arrangement. The chain wheel is splined to the drive gear. Limit stops prevent overtravel of the hook at both the upper and lower limits and dual braking is provided. The motor is of the high-starting-torque, reversible type with the bearings sealed in grease. It operates on 3-phase, 60-cycle current of either 220 or 440 volts.

## Engine-Driven Battery Charger

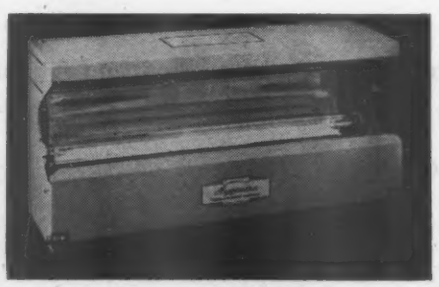
A portable battery charger for recharging batteries in railway passenger cars is being manufactured by The Hobart Brothers Company, Troy, Ohio. The generator is a 300-amp., 45-volt, d.c. flat compound-wound machine connected directly to a Chrysler T-118 six-cylinder self-starting gasoline engine with battery ignition. The set is mounted on a steel-wheeled truck with hand towing tongue, complete with separate but inbuilt exciter, control-panel cabinet, ammeter with shunt, voltmeter, generator-field rheostat and disconnecting switch. There are two separate 150-amp. charging circuits and generator overload protection is provided with 175-amp., 250-volt Fusetrons. The set is protected for outdoor service by a weatherproof canopy with doors that can be closed after the machine has been properly set for charging.



The set is designed to supply two 150-amp. charging circuits

## Air Sterilizer

Equipment for disinfecting air by means of an ultraviolet radiation known as the Hygeaire system is now being made by the American Sterilizer Company, Erie, Pa. The Graybar Electric Company and General Electric Supply Corporation are the distributors. The equipment is a combination of a GE germicidal tube and a patented reflector in a fixture designed to project a zone of protection across the area at eye-level. Air-borne bacteria and viruses are carried into the zone of ultraviolet light and to their deaths by convected air currents. The manufacturers state that the unit gives to the protected space the germicidal effect of 100 air changes per hour. Features claimed for the equipment are low initial and operating costs, ease of installation and tube replacement, and long life.



One of the units of the Hygeaire system

## Speed Indicator

A speed measuring device, which adds the number of revolutions over a period of six seconds and shows the revolutions per minute without any calculations, is being offered under the name of Jaeger speed indicator, by the James G. Biddle Company, Philadelphia, Pa. The indicator differs from the conventional centrifugal type tachometer in that it does not show instantaneous speed or speed variations. Instead the hands stop automatically at positions which indicate the measured speed. Both r.p.m. and feet per minute speeds can be measured.

Jaeger speed indicator

The instrument consists of a special non-magnetic watch movement combined with a revolution counter in such a way that the revolutions are timed for exactly six seconds. As this is proportional to the revolutions per minute, the scale is calibrated in r.p.m. There are two ratings for the instrument, one for all speeds up to 2,000 r.p.m. and the other for speeds up to 10,000 r.p.m. The indicators are adjusted to an accuracy within one-half of one per cent at all speeds above 50 r.p.m. for the low-speed instrument and 100 r.p.m. for the high-speed instrument.



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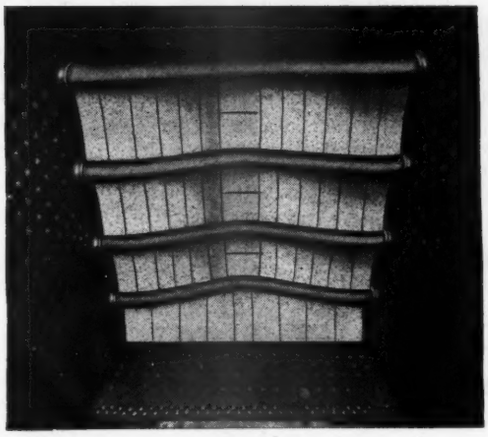
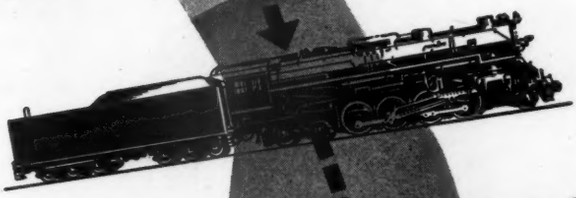


# TAKE THIS STEP FOR COAL CONSERVATION

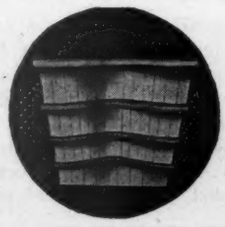


**Coal on the tender represents not only certain dollars of expense but priceless man hours as well. Therefore, its careful conservation is a wartime duty**

**« « A generation of railroad men have learned that Security Sectional Arches are easy on the coal pile. A complete arch in every locomotive firebox is a fundamental step towards fuel conservation.**

**HARBISON-WALKER REFRACTORIES CO.**

***Refractory Specialists***



**AMERICAN ARCH CO.**
**INCORPORATED**
**60 EAST 42nd STREET, NEW YORK, N. Y.**
***Locomotive Combustion Specialists***

## Insulation Tester

A Model C-2 Megohmer for testing electrical insulation has been announced by the Herman H. Sticht Company, Inc., New York. The instrument incorporates a spillproof lightweight storage battery from which is obtained the necessary 500 volts d.c. for testing. The battery voltage is stepped up by a vibrator transformer circuit built into the instrument. There is also a charging circuit which allows recharging to the battery from either alternating or direct current. The instrument has a sensitive meter movement with knife-edged pointer and mirror scale which reads directly in megohms and ohms.

**Megohmer in which testing voltage is supplied by a storage battery**

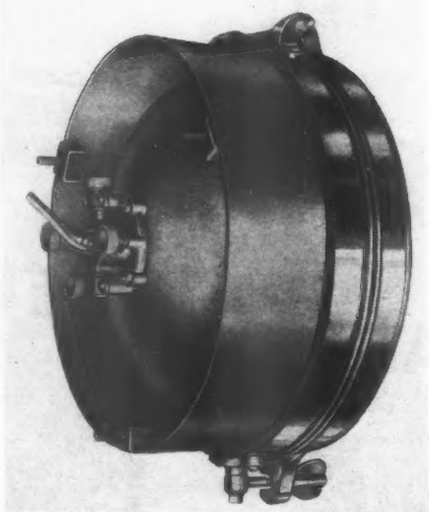
## Arc Welder

A lightweight, engine-driven welder rated at 200 amp., with a rubber mounted engine of 29 hp., is announced by The Lincoln Electric Company, Cleveland, Ohio. It is supplied complete with base and canopy and has a current range of 40 to 250 amp. Dual control of welding current is accomplished by adjustment of series fields and generator speed. The generator control assures accuracy of open circuit voltage and permits precise control of engine speed of from 1,500 to 1,150 r.p.m. for welding. These low speeds are used to insure long life of the equipment. The generator will produce 200 amp. at 1,200 r.p.m. In addition, this control may be used to manually reduce the engine speed to as low as 750 r.p.m. to reduce fuel consumption whenever it is necessary to stop welding at intervals of a few minutes. Weight of the unit as illustrated is approximately 1,130 lb. Overall length is 65¼ in.; width, 24 in.; and height, 41½ in.

**Lincoln, 200-amp. engine-driven welder**

## Locomotive Headlight

Headlights designed for practically flush installation on streamlined equipment are manufactured by the Electric Service Supplies Company, Philadelphia, Pa. Known by the trade name Golden Glow they are equipped with non-deteriorating glass mirror reflectors which are readily cleaned and afford continual maximum intensity of beam. The reflectors are permanently attached to the door frame which does not permit training but three mounting lugs are provided to make it possible to adjust the light for proper direction. Focusing devices are available or a socket can be furnished for use with prefocused lamps. The headlights are built for use with 100- to 250-watt, 32-volt, concentrated-filament headlight lamps up to and including P-25 size.



**Flush-mounting on streamlined equipment is a design feature of this headlight**

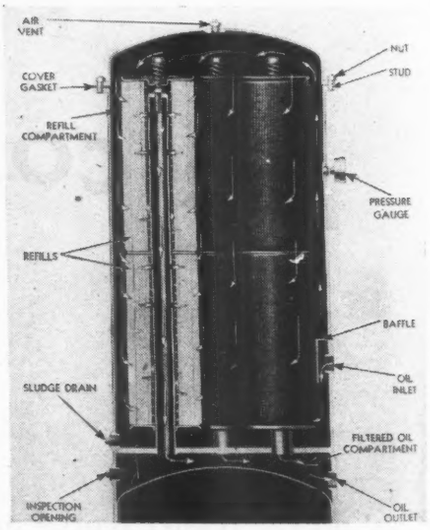
## Fire Extinguisher Uses Dry Chemical

A fire extinguisher employing a dry chemical as the extinguishing agent has been placed on the market by the National Powder Extinguisher Corporation, New York. It is designed especially for use on both flammable liquids and fires of electric origin and ejects a stream of dry chemical which, when activated by heat, is said to form a dense, fire-smothering cloud over a flaming area up to 18 ft. across. The insulating qualities of the cloud are also said to help guard against re-flash and to create a heat-deflecting screen between the operator and the flame. These qualities permit a closer range attack with greater safety and a minimum of heat discomfort to the operator.

The chemical employed is reported to be a non-conductor of electricity and harmless to humans or delicate parts of motors and other machinery. Fully charged, the unit weighs 37 lb. It is said to be fast in action and can be quickly recharged without special recharging equipment. Both the extinguisher and the extinguishing agents employed have been approved by the Associated Factory Mutual Laboratories on burning oil, alcohol and gasoline fires.

## Oil Filters For Diesel Engines

Clarifiers with flow capacities which range up to 500 g.p.h. are now available in the line manufactured by the Briggs Clarifier Company, Washington 7, D. C. Maximum working pressures and hydrostatic test pressures have been established to meet specific demands of the application. For small high-speed Diesel engines where pressures are high the clarifiers are designed for a maximum working pressure of 100 lb. per sq. in. and are hydrostatically tested to 150 lb. For larger heavy-duty units where working pressures are not so great the clarifiers are designed for these lesser pressures. Pressure drop across the refills ranges from 0 to 5 lb. per sq. in.




**Sectional view of the Briggs fuel oil clarifier**

Provision is made for registering the pressure differential across the refill cartridges by installing one gauge in the upper compartment and another in the lower compartment of the tank. Operators can tell the exact pressure differential easily and are able to determine from it when refill cartridges should be installed. The company is prepared to deal also with special applications.

*(Turn to next left-hand page)*

The ELESCO exhaust steam injector provides the highest fuel economy of any type of feedwater heater per unit of weight and cost. Apply them and save vital fuel.

ELESCO

A-1599 (A-1250)

THE SUPERHEATER COMPANY

SUPERHEATERS • FEEDWATER HEATERS
AMERICAN THROTTLES • STEAM DRYERS
EXHAUST STEAM INJECTORS • PYROMETERS

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THE SUPERHEATER COMPANY, LTD.

# NEWS

## V. V. Boatner of O. D. T. Resigns

VICTOR V. BOATNER, director of the Division of Railway Transportation of the Office of Defense Transportation, resigned on April 1. Mr. Boatner, who had held this post since it was established, will continue to be available in an advisory capacity whenever it becomes necessary to call upon him. He has been succeeded as acting director of the division by James H. Aydelott, formerly deputy director.

## Three Per Cent Loading Rise Seen for Second Quarter

FREIGHT carloadings in the second quarter of 1944 are expected to be about three per cent above actual loadings for the same quarter of 1943, according to estimate compiled by the 13 Regional Shippers' Advisory Boards.

On the basis of those estimates, loadings of the 28 principal commodities will be 9,209,507 cars, compared with 8,943,554 actual carloadings for the same commodities in the corresponding period in the preceding year. Seven of the 13 boards estimated an increase over 1943 in second-quarter loadings, while three estimated decreases. With respect to commodities, increased loadings were estimated for 17 and decreases for 11.

## Correction—Missouri Pacific Locomotives

In the article describing the Missouri Pacific 4-8-4 type locomotives which appeared in the April, 1944, issue, the weight proportions in the table appearing on page 152 should be:

| | |
|---|---|
| Weight on drivers, per cent of engine weight | 57.2 |
| Weight on drivers ÷ tractive force | 4.17 |
| Weight of engine ÷ evaporative heat. surface | 92.1 |
| Weight of engine ÷ comb. heat. surface | 65.0 |

These proportions are based on a total engine weight of 489,000 lb. which was the final weight of the locomotives.

## J. Monroe Johnson Succeeds Eastman

J. MONROE JOHNSON has been appointed to the directorship of the Office of Defense Transportation, succeeding the late Joseph B. Eastman. Colonel Johnson, who remains a member of the Commission with relief from routine duties, continues to serve on Division 3 and to retain supervision of the Bureau of Service. His role with the commission is thus larger than was Mr. Eastman's who functioned under leave-of-absence arrangements which brought him into commission deliberations only when his vote was necessary to break a tie.

Brig. Gen. Charles D. Young, who has been acting director of ODT since Mr. Eastman's death, will continue in the position of deputy director which he held under Mr. Eastman.

Colonel Johnson has been a member of the commission since June, 1940, shortly after which time he was placed in charge of the Bureau of Service, the Bureau having charge of the use, control, supply, movement, distribution, exchange, interchange and return of locomotives, cars and other vehicles used in the transportation of property. At present the bureau is engaged in administering the commission's wartime emergency powers.

Colonel Johnson is a civil engineer. He was born in Marion, S. C., May 5, 1878, and received his education in the Marion public schools and at the University of South Carolina and Furman University. He is a member of the American Society of Civil Engineers, and the Society of American Military Engineers, of which he was national president in 1940, and at present is a member of its executive committee. He is also a charter member of the American Legion. He was awarded a Distinguished Service Medal by the United States; the Verdun Medal and Legion of Honor by France, and the Order of Leopold II by Belgium in the first world war during which he served with the First Battalion, 117th Engineers, Rainbow Division — as major until April, 1918, and then as lieutenant colonel. His promotion to colonel came in October of that year, but he had meanwhile, in September, assumed command of the regiment and became chief engineer of the Rainbow Division.

Colonel Johnson anticipates that ODT will continue to function much the same as in the past.

## J. E. Davenport Addresses Western Railway Club

AT the regular monthly meeting of the Western Railway Club, held at Chicago on Monday evening, April 17, J. E. Davenport, vice-president, American Locomotive Company, presented a comprehensive picture of present railway motive-power developments and future possibilities in a paper entitled "Tomorrow's Locomotives." Mr. Davenport reviewed the respective advantages and operating characteristics of all the major types of locomotives now in use or contemplated for American railroads and emphasized the dominant part which motive power can and must play in winning the war and handling the nations traffic in the postwar period.

Following Mr. Davenport's paper, prepared discussions of the same subject were presented by A. J. Townsend, chief mechanical engineer, Lima Locomotive Works, Inc., who emphasized the great improvements already effected in modern steam locomotives, and by R. P. Johnson, chief engineer, The Baldwin Locomotive Works, who pointed out that two of the advantages of Diesel motive power, namely, standardization and availability are applicable to an increased extent to steam locomotives if railroads really care to work on it.

## Miscellaneous Publications

"FASTENERS." — American Institute of Bolt, Nut, and Rivet Manufacturers, Cleveland, Ohio. "Fasteners" is intended to provide engineers and executives with factual engineering data on important developments in the fastener industry. A program of technical research has been inaugurated and a number of subjects never before thoroughly investigated are being studied. The facilities available for the first such project already under way at the Technical Institute of Northwestern University are illustrated in this first edition of the publication.

## Backlog of Freight Cars on Order Increasing

THE large volume of freight-car buying currently taking place has resulted in an increase in the backlog of cars on order and undelivered. As of April 1, the backlog had increased to about 45,000 cars, as compared with 43,300 on March 1 and 38,100 at the end of 1943. Of the 45,000 cars, 28,400 were on order with contract car builders and 16,600 with railroad shops. The number of cars on order but without War Production Board authorization to build was reduced during March to 3,200 at April 1 from 3,900 at March 1. The 41,800 authorized for building were divided about as follows: 500 remaining to be shipped of the number authorized from third quarter, 1943 materials; 4,000 from fourth quarter, 1943 materials; 9,900 from first quarter, 1944 materials; 15,500 released in advance from second quarter, 1944 materials; 9,800 from third quarter, 1944 materials, and 2,100 from fourth quarter, 1944 materials.

## Purchases in 1943 Greatest Since 1927

PURCHASES of fuel, materials and supplies by Class I railroads of the United States in connection with their operation were greater in 1943 than in any other year since 1927, according to J. J. Pelley, president of the Association of American Railroads. Such purchases in 1943 totaled $1,394,281,000, an increase of $134,470,000 compared with 1942. In 1927 purchases of fuel, materials and supplies totaled $1,395,928,000.

Purchases increased 10.7 per cent between 1942 and 1943. Part of this increase was due to increased prices, which averaged about 7 per cent higher in 1943 than in 1942, and the remainder was due to greater volume purchased.

Class I roads in 1943 expended $527,296,-

000 for fuel compared with $426,335,000 in 1942. For bituminous coal only, their purchases totaled $375,398,000 or an increase of $62,611,000 compared with the preceding year, while anthracite purchases totaled $3,715,000, or an increase of $625,000 compared with 1942. Purchases of fuel oil in 1943 amounted to $136,905,000, compared with $99,767,000 in the preceding year. For gasoline, there was an expenditure of $5,782,000 in the past year, while for all other fuels, including coke, wood, and fuel for illumination, expenditures amounted to $5,496,000.

Class I roads in 1943 purchased iron and steel products amounting to $410,803,000, compared with $433,089,000 in 1942, or a decrease of $22,286,000. For locomotives and car castings, beams, couplers, frames and car roofs, the railroads spent $49,440,000 in 1943, compared with $61,359,000 in the preceding year.

For wheels, axles and tires, the railroads expended $44,550,000, compared with $41,501,000 in the preceding year; and for bar iron and steel, spring steel, tool steel, unfabricated rolled shapes, wire netting and chain, boiler, firebox, tank and sheet iron and steel of all kinds their expenditures amounted to $28,868,000, compared with $27,120,000 in the preceding year. Purchases of special mechanical appliances for locomotives amounted to $18,478,000.

Miscellaneous purchases made by the Class I roads totaled $305,927,000 in 1943 compared with $285,160,000 in 1942. Among the items coming under this heading were $30,468,000 for lubricating oils and grease, illuminating oils, boiler compound and waste; $19,783,000 for electrical materials; $29,544,000 for non-ferrous metals and products; $7,631,000 for passenger-car trimmings; and $22,463,000 for locomotive, train and station supplies.

## Locomotives on Order as of March 1

CLASS I roads had 779 locomotives on order on March 1, compared with 499 on the same day in 1943. The former figure included 264 steam and two electric and 513 Diesel-electric locomotives, contrasted with 352 steam and 147 electric and Diesel-electric one year ago.

The Office of Defense Transportation reported that railroads, other than Class I, had 51 new locomotives on order on March 1.

## Betterton Appointed Director of WPB Equipment Division

G. M. BETTERTON, general purchasing agent of the Southern Pacific with headquarters at San Francisco, Calif., has succeeded Albert C. Mann, vice-president of the Illinois Central, as director of the Transportation Equipment Division, War Production Board. His appointment became effective April 1 when Mr. Mann returned to the Illinois Central.

Mr. Mann has been director since last December when he succeeded Lynne L. White, who returned to his position as chief operating officer of the Chicago & North Western after having served three months as successor to Andrew Stevenson.

## 105,901 Women in Railroad Service

DURING the three-month period from mid-October, 1943, to mid-January, 1944, the number of women employees of Class I railroads showed an increase from 103,209 to 105,901—according to the most recent figures of the Bureau of Transport Economics and Statistics of the Interstate Commerce Commission, but the rate of increase was not so large as in the preceding quarterly period.

In January, 1943, when the compilation of these data was first made public by the bureau, a total of 63,187 women were employed on Class I roads. In the maintenance of equipment and stores division the January, 1944, total was 21,545, as compared to 9,439 at the same time last year.

## Capital Expenditures in 1943 Below 1942

CAPITAL expenditures for equipment and other improvements to railway property made by Class I railroads in 1943 totaled $454,282,000, a decrease of $80,615,000 below those made in 1942, according to the Association of American Railroads.

Capital expenditures for equipment were $93,393,000 below those in 1942, but expenditures for roadway and structures were $12,778,000 above the preceding year.

Capital expenditures for locomotives in 1943 totaled $142,070,000 compared with $113,834,000 in 1942, and $80,607,000 in 1941. In 1940, capital expenditures for locomotives amounted to $54,351,000 and in 1939 they were $42,807,000 as compared to $208,966,000 in 1933.

For freight-train cars, capital expenditures in 1943 amounted to $97,890,000, which was less than in any of the preceding three years but an increase of $31,111,000 compared with 1939. For passenger-train cars, the amount of capital expenditures totaled $5,828,000 in 1943, which was considerably less than the amount spent for such purposes in any of the preceding nine years. In 1942 such expenditures totaled $24,075,000 and in 1941 they were $29,544,000. Expenditures for passenger-train cars in 1940 amounted to $18,417,000 and in 1939 they were $19,723,000. For other equipment, expenditures last year amounted to $10,193,000 compared with $10,353,000 in 1942, and $11,704,000 in 1941.

Last year's capital outlay of $454,282,000 was $399,551,000 less than the total of capital expenditures which had been authorized, including the carry-over from 1942. The latter amounted to $267,848,000 to which was added the $585,985,000 additional authorizations during last year to bring the 1943 total to $853,833,000. The unexpended $399,551,000 now carried over into the current year includes $214,923,000 for equipment and $184,628,000 for roadway and structures.

## Improvement Programs

*Canadian National.*—The Canadian National has awarded a contract, amounting to $40,000, to W. C. Wells, Wilkie, Sask., for improvements to the enginehouse, ma-

(*Continued on second left-hand page*)

## Orders and Inquiries for New Equipment Placed Since the Closing of the April Issue

LOCOMOTIVE ORDERS

| Road | No. of Locos. | Type of Loco. | Builder |
|---|---|---|---|
| New York Central | 1[1] | 4-8-4 | American Loco. Co. |
| New York, New Haven & Hartford | 20 | 2,000-hp. Diesel-elec. | American Loco. Co. |
| | 12 | 1,000-hp. Diesel-elec. | American Loco. Co. |
| | 10 | 44-ton Diesel-elec. | General Elec. Co. |

LOCOMOTIVE INQUIRIES

| Road | No. of Locos. | Type of Loco. | Builder |
|---|---|---|---|
| Chesapeake & Ohio | 6 | 4-6-4 | |
| Western Maryland | 5 | 4-8-4 | |

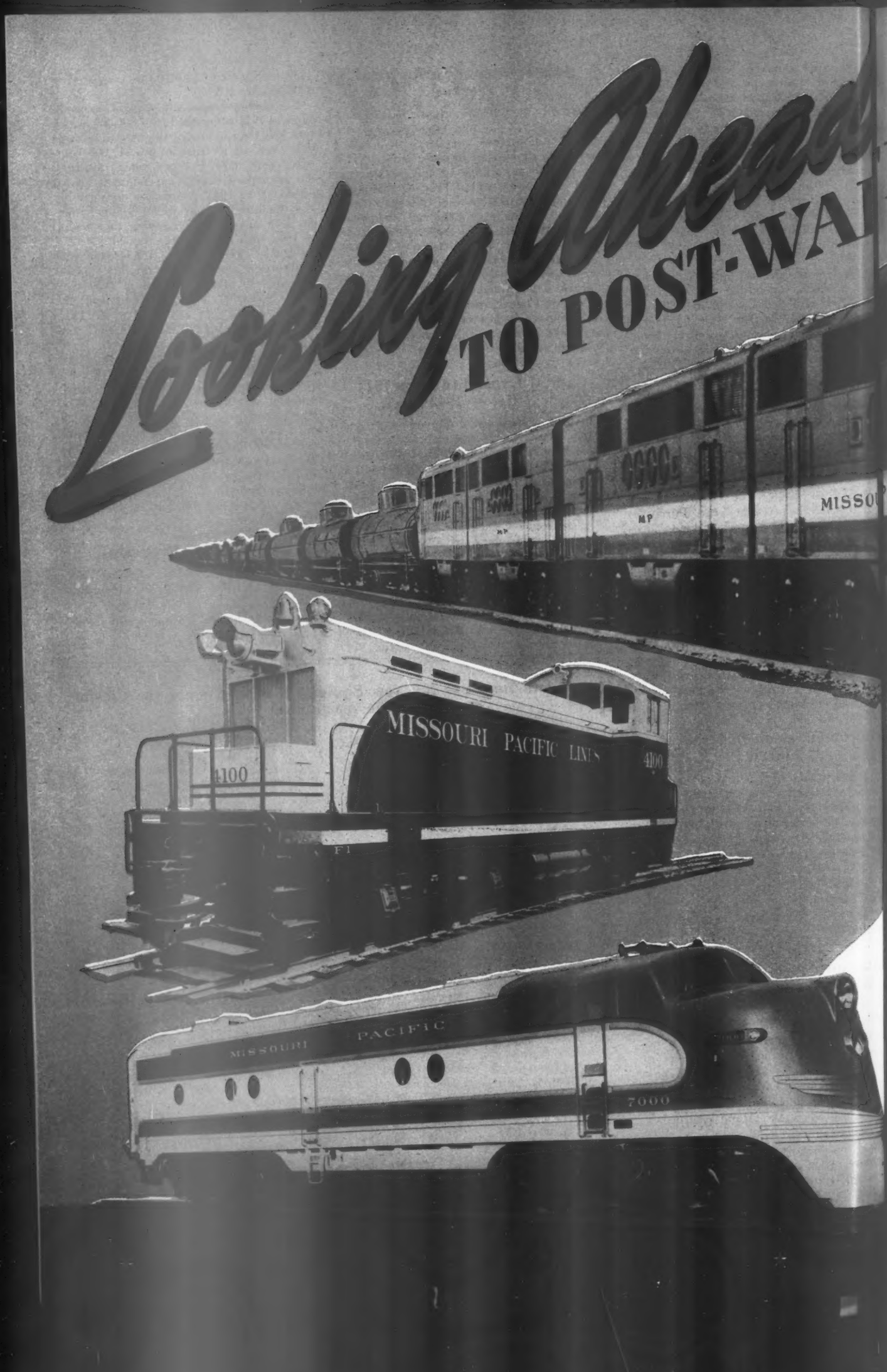
FREIGHT-CAR ORDERS

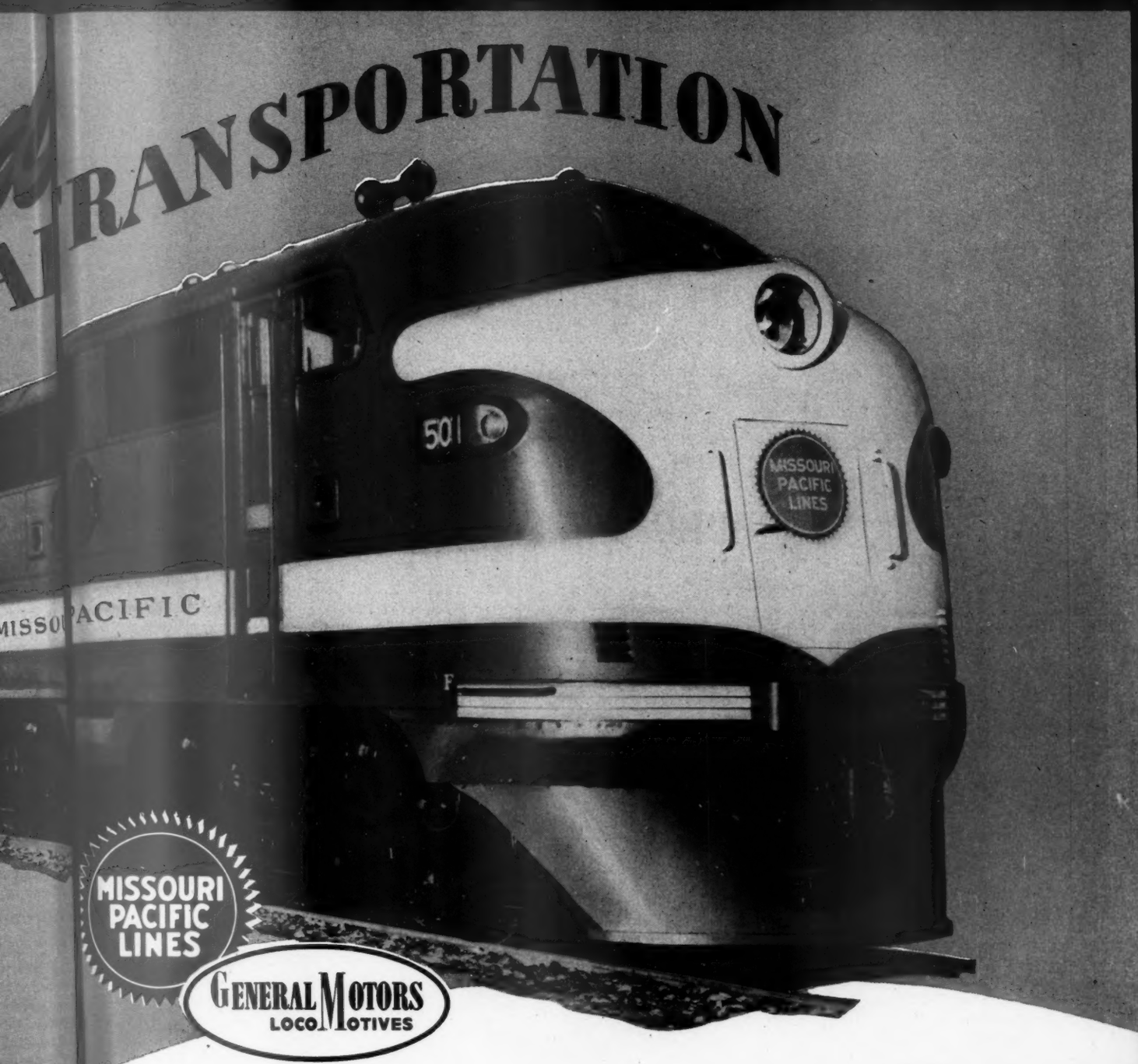
| Road | No. of Cars | Type of Car | Builder |
|---|---|---|---|
| American Refrigerator Co. | 100[2] | 40-ton refrigerator | Co. shops |
| Bangor & Aroostook | 35 | 50-ton hopper | American Car & Fdry Co. |
| Chicago & North Western | 800 | 50-ton box | American Car & Fdry Co. |
| | 600 | 50-ton box | Gen. Amer. Trans. Corp. |
| | 600 | 50-ton box | Pull.-Std. Car Mfg. Co. |
| Chicago, Rock Island & Pacific | 500 | 50-ton box | Pressed Steel Car Co. |
| Delaware, Lackawanna & Western | 250[3] | 50-ton box | Magor Car Corp. |
| | 350[3] | 50-ton box | American Car & Fdry Corp. |
| Lehigh & New England | 300[4] | 50-ton hopper | Bethlehem Steel Co. |
| Missouri Pacific | 100[5] | 40-ton stock | Co. Shops |
| New York Central | 1,000 | 55-ton box | Despatch Shops, Inc. |
| | 1,000 | 55-ton hopper | Despatch Shops, Inc. |

FREIGHT-CAR INQUIRIES

| Road | No. of Cars | Type of Car | Builder |
|---|---|---|---|
| Chicago & Eastern Illinois | 200 | 50-ton hopper | |
| National Tube Co.[6] | 30 | 70-ton hopper | |
| Norfolk & Western | 500 | 50-ton box | |
| Reynolds Metals Co.[6] | 25 | 50-ton box | |
| St. Louis-San Francisco | 50 | 70-ton hopper | |
| Western Pacific | 100 | 70-ton gondola | |
| Wheeling & Lake Erie | 500 | 50-ton box | |
| | 500 | 50-ton gondola | |

[1] Experimental.
[2] Deliveries expected to be completed during latter part of this year.
[3] Allocations incorrectly reported in the April issue.
[4] Deliveries scheduled for September and October.
[5] For International-Great Northern.
[6] Inquiry unconfirmed.


Looking Ahead
TO POST-WA
MISSOURI PACIFIC LINES
4100
MISSOURI PACIFIC
7000




Right from the start, the first of the new Missouri Pacific Diesel Freight Locomotives made history when it broke all existing load and speed records on the railroad by hauling 115 cars, totaling 4339 tons, on its 515 mile maiden run from Dupo, Illinois, to Texarkana, Texas, in 20 hours and 8 minutes. This running time was almost 14 hours ahead of the schedule for "symbol" oil trains, which are the hottest and fastest freight trains handled by this or any other railroad. ***But this inaugural run was only the beginning.*** On the return trip with 120 loaded tank cars and 3 empties, the "Big Jeep" (as it has been dubbed by the operators) made the trip in 18 hours and 15 minutes, hauling 6835 actual tons which, so far as is known, constituted what was then a train load record. However, this mark was doomed for a fall. On the Texarkana-Dupo run of December 13, 1943, the General Motors 5400 Hp. Diesel Freight Locomotive handled 7064 actual tons, pulling 124 loads and 3 empties. At this time, these two 5400 Hp. Freight Diesels are being operated as four 2700 Hp. locomotives until additional Freight Diesels are received. Two 2700 Hp. Freight Diesels are now operating between Dupo and Alexandria and two between Dupo and Texarkana.

ELECTRO-MOTIVE DIVISION

ENERAL MOTORS CORPORATION LA GRANGE, ILLINOIS, U.S.A.

chine shop and boiler room at Calgary, Alta.

*Missouri Pacific.*—An extensive program of construction and improvement work is contemplated in 1944 on the Missouri Pacific Lines, contingent on approval by the War Production Board and other factors. Among the principal items on this program are the following:

A 400,000-gal. Diesel oil storage tank will be installed at Dupo, Ill., and a 100,000-gal. tank at Texarkana, Ark.; the purchase of a spare four-wheel Diesel locomotive power truck, complete with two traction motors, and a spare 16-cylinder 1,350-horsepower Diesel engine.

Improvements proposed for Dupo, Ill., include the extension of thirteen 85-ft. enginehouse stalls to a length of 120 ft., the relocation of a water tank and the boiler washout plant, the installation of two 300-hp. water-tube boilers complete with combustion control, and ash and coal handling facilities, to replace a pair of 250-hp. hand-fired boilers.

New mechanical appliances and appurtenances include a 50-in. car-wheel lathe, for St. Louis, Mo.; a turret lathe and horizontal milling machine for North Little Rock, Ark.; a vertical boring mill, horizontal milling machine and four portable electric welders for Sedalia, Mo.; an engine lathe and 6,000-lb. lift truck for Osawatomie, Kan.; a crane truck with telescopic boom for Coffeyville, Kan.; an engine lathe for Kingsville, Tex.; and a milling machine for South San Antonio, Tex.

The 1944 improvement program also contemplates the application of roller bearings and other improvements to 11 locomotives, 10 mechanical stokers, 20 Thermic syphons, 10 radial buffers, and of 75 force-feed lubricators. The railroad also plans general repairs and betterments on 2,057 freight cars; to rebuild three mail cars; and to purchase two four-wheel spare trucks for the "Eagles."

*Northern Pacific.*—The Northern Pacific's program of equipment purchases and additions and betterments to railroad property calls for expenditures of $20,500,000, according to C. E. Denney, president. The more important 1944 projects include among other things the construction of Diesel road locomotive shops at Auburn, Wash., $500,000; and an addition to the locomotive shops at Livingston, Mont. (started last fall), $1,500,000.

# Supply Trade Notes

LOCOMOTIVE FIREBOX COMPANY.—The Locomotive Firebox Company has transferred its eastern office from New York to 12 South 12th Street, Philadelphia, Pa.

◆

AMERICAN LOCOMOTIVE COMPANY.—*Alexander M. Hamilton*, executive vice-president of the Montreal Locomotive Works, Canadian subsidiary of the American Locomotive Company, has been appointed vice-president, foreign sales, of the American Locomotive Company. Mr. Hamilton joined the company in 1909 following his graduation from Cornell University with a degree in mechanical engineering. After working in the Schenectady, N. Y., plant, he was transferred to the foreign sales division in New York and, in 1915, sent to Russia to supervise the erection of locomotives sold to that country. During the first world war, he served in the United States field artillery. He returned to the American Locomotive Company and was European representative with headquarters in Paris until 1921. He was subsequently foreign sales representative for the company in various parts of the world, and in 1942 was appointed executive vice-president of the Montreal Locomotive Works.

Alexander M. Hamilton

OLIVER IRON & STEEL CORPORATION.—*Ernest Schleusener* has been elected vice-president in charge of operations, and *John P. Roche*, secretary and assistant to the president, of the Oliver Iron & Steel Corporation. Mr. Schleusener was graduated with a degree in mechanical engineering from the Carnegie Institute of Technology. He served in various executive capacities in the Oliver plant and in May, 1942, was appointed assistant vice-president in charge of engineering and production control. Mr. Roche was graduated from Duquesne University and the University of Pittsburgh Law School.

Ernest Schleusener

CHICAGO RAILWAY EQUIPMENT COMPANY.—*Samuel J. Walker*, assistant to the president of the Chicago Railway Equipment Company, has been elected vice-president, with headquarters as before at Chicago.

◆

BALDWIN LOCOMOTIVE WORKS.—*Ray S. Quick* has been appointed in charge of a district sales office opened by the Baldwin Locomotive Works at 2929 Nineteenth Street, San Francisco, Calif. Mr. Quick is also manager of the Pelton Water Wheel Company, a Baldwin division. The new office will handle sales of all divisions of the company and, in addition to covering the Pacific coast district, will direct sales of Baldwin products in the territories of Alaska and Hawaii. Mr. Quick was graduated from the University of California in 1916 and from the University of Illinois in 1919 with degrees in electrical engineering. He served in the United States Army as a second lieutenant in the signal corps from 1917 to 1919 and subsequently was employed by the Pelton Water Wheel Company serving successively as sales engineer, executive engineer, chief engineer, and general manager.

Ray S. Quick

## Army-Navy "E" Awards

*American Car & Foundry Company*, Wilmington, Del. Fourth renewal.

*Copperweld Steel Company*, Glassport, Pa. Renewal.

*Ohio Injector Company*, Wadsworth, Ohio. Third renewal.

LANDIS MACHINE COMPANY.—*John H. Elliott,* for the past four years secretary of the Landis Machine Company, Waynesboro, Pa., has been appointed general manager. Mr. Elliott will continue also as secretary.

◆

HARNISCHFEGER CORPORATION.—*E. W. Potratz,* assistant sales manager of the Harnischfeger Corporation, Milwaukee, Wis., has been appointed manager of the Hoist Sales division. *Benjamin Van Horn,* manager of the Crane Sales division, has retired after 47 years' service with that company.

◆

WHITING CORPORATION—The *William H. Ziegler Company* of Minneapolis, Minn., have been appointed exclusive sales representatives of the Whiting Corporation in the Twin Cities territory.

◆

CUTLER-HAMMER, INC.—*G. E. Hunt,* manager of the Indianapolis, Ind., office of Cutler-Hammer, Inc., has been appointed acting manager of the company's Atlanta, Ga., territory.

◆

ELECTRO-MOTIVE DIVISION, GENERAL MOTORS CORPORATION.—*Ernest Kuehn,* special representative of the vice-president of General Motors, has been appointed manager of the Pacific Coast region of the Electro-Motive Division of the General Motors Corporation, with headquarters at 2913 Russ building, San Francisco, Calif. Mr. Kuehn was superintendent of motor cars of the St. Louis Southwestern from 1914 to 1921. From 1921 to 1923 he owned and operated the J. S. Shock Spring Company, St. Louis, Mo. He went with the Electro-Motive Company when it was formed in 1923 as mechanical manager in charge of production and service, and when the construction of the Electro-Motive plant was authorized in 1935, Mr. Kuehn

**Ernest Kuehn**

was appointed factory manager. He laid out and supervised the building of the plant and served as factory manager until 1942 when he was appointed special representative of H. L. Hamilton, vice-president of General Motors, assigned to Electro-Motive.

FRANKLIN RAILWAY SUPPLY COMPANY, BALMAR CORPORATION.—*Herman F. Ball,* president of the Franklin Railway Supply Company for the past 27 years, has been elected vice-chairman of the board of direc-

**Herman F. Ball**

tors of that company, and *George W. Alcock,* vice-president, has been elected president to succeed Mr. Ball. Mr. Alcock has been elected also chairman of the board of the Balmar Corporation, a subsidiary of the Franklin Railway Supply Company, of which he was formerly president. *John*

**G. W. Alcock**

*N. Merkle,* executive vice-president of the Balmar Corporation, succeeds Mr. Alcock as president.

*Herman F. Ball* began his carreer in 1884 as an apprentice in the Altoona, Pa., carbuilding shops of the Pennsylvania where he served until 1888. He was a draftsman in the office of the mechanical engineer of that railroad from 1888 to 1890. He joined the Lake Shore & Michigan Southern in 1890, serving successively as chief draftsman in the car department, general foreman in the car shops, general car inspector, mechanical engineer and superintendent of motive power. He resigned from the Lake Shore & Michigan Southern in 1906 when he was appointed vice-president of the American Locomotive Company. He was elected president of the Economy Devices Corporation in 1913 and president of the Franklin Railway Supply Company in 1917.

*George W. Alcock* served in the engineering department of the American Locomotive Company from 1902 to 1917 and in the production division of the U. S. Army ordnance department during the first world war after which he entered the sales department of the Lima Locomotive Works. In 1936 he was appointed assistant to the president of the Franklin Railway Supply Company and in 1940 was elected vice-president.

*John N. Merkle* joined the Franklin Railway Supply Company in 1911. He

**John N. Merkle**

was transferred to the Franklin Railway Supply Company, Ltd., Montreal, Canada in 1917, and in 1918 returned to the Franklin Company in New York where he remained until 1935 when the Balmar Corporation was formed.

◆

BRIDGEPORT BRASS COMPANY.—*Mead W. Batchelor,* works manager of the mill division, has been appointed a vice-president, and *A. Dean Merwin,* sales manager of the fabricating division, has been appointed assistant secretary of the Bridgeport Brass Company.

◆

DOUGLAS FIR PLYWOOD ASSOCIATION.—*Donald M. Crooks,* formerly in charge of engineering of the Hayward Lumber & Investment Co., Los Angeles, Calif., has been appointed Midwest representative of the Douglas Fir Plywood Association with headquarters in Chicago. Mr. Crooks succeeds *David S. Beteone* who has been made Eastern representative at Washington, D. C.

◆

SYLVANIA ELECTRIC PRODUCTS, INC.—*Charles H. Goddard,* formerly vice-president of the Pittsburgh Reflector Company, has been appointed product manager, fluorescent fixture sales, for Sylvania Electric Products Inc.

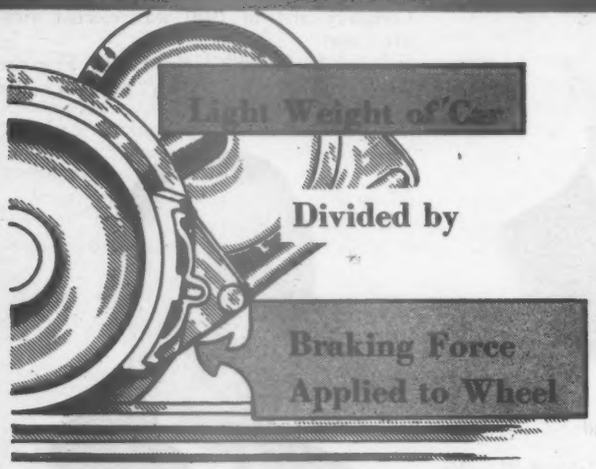
◆

YOUNG RADIATOR COMPANY.—*R. P. Exten,* formerly production engineer of the Mechanics Universal Joint and Rockford Drilling Machine division of the Borg-Warner Corporation, Rockford, Ill., has been appointed executive assistant to the president of the Young Radiator Company, Racine, Wis.



(*Turn to second left-hand page*)

# SPEED GOVERNOR CONTROL
## *of Braking Ratios*




## Braking Ratio

**The relation between the braking force applied to the wheel and the car weight expressed in percentage. Thus—**

**150% BRAKING RATIO—1½ TIMES THE CAR WEIGHT**

**250% BRAKING RATIO—2½ TIMES THE CAR WEIGHT**

## 150% BRAKING RATIO

**Used in Regular Passenger Service**

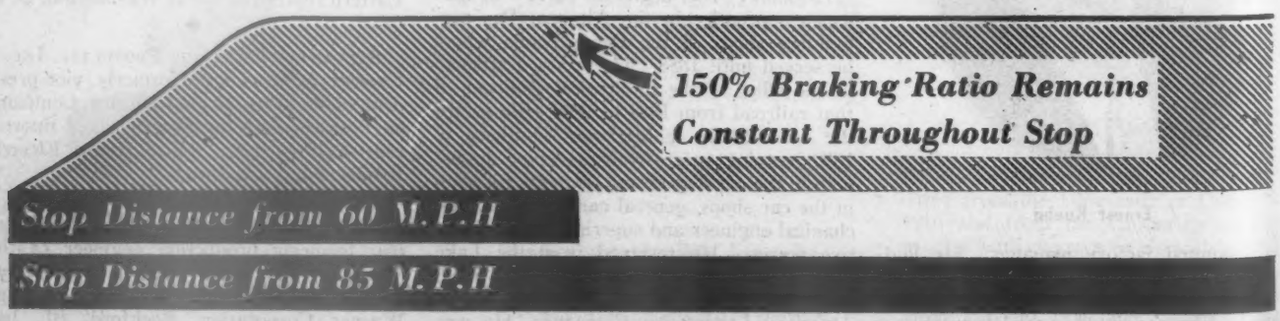
For brake equipments where the braking ratio cannot be regulated, experience has shown that 150% is the maximum that can be employed. This became established when 60 M.P.H. was the maximum train speed.

## HIGHER BRAKING RATIOS

**Required for Stops from Higher Speeds**

The chart below shows the stop distance relation if the customary 150% braking ratio were used for stops from higher speeds. With an increase in speed of 25 M.P.H. the stop distance is about doubled. This is because of the tremendous increase in energy developed within the train at the higher speed. Therefore, to shorten the stop distance, it is necessary to use higher brake shoe forces. On modern high speed trains braking ratios up to 250% are solving the problem.

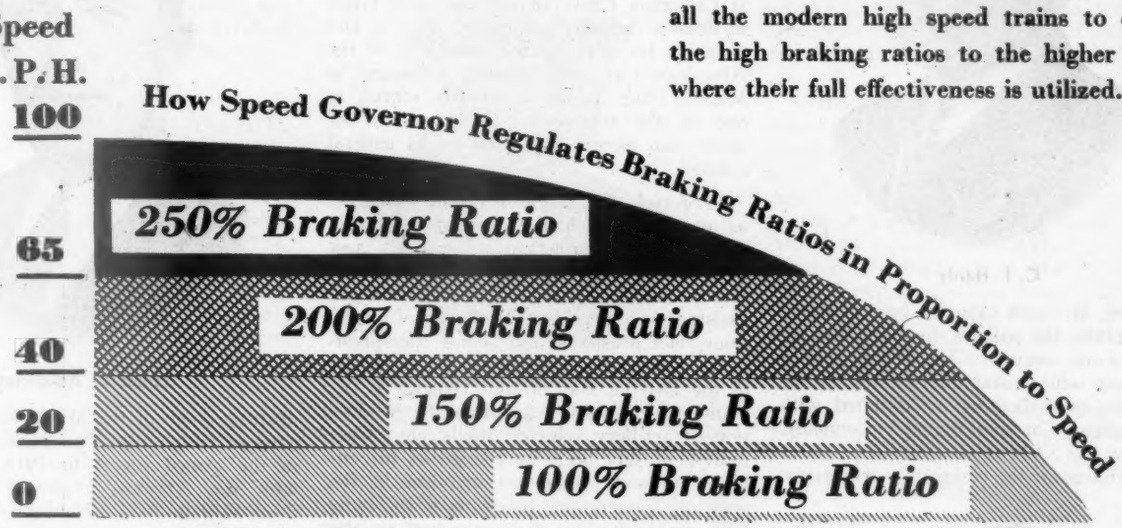
But the increased braking ratios assuredly would cause wheel sliding at the lower speeds if the higher ratios were maintained throughout the stop or used at the lower speeds, as followed in regular service with a constant 150% braking ratio.




# WESTINGHOUSE AIR BRAKE

# *for Shorter, Smoother Stops from* HIGH SPEEDS

SPEED GOVERNOR CONTROL, therefore, was developed and is used on practically all the modern high speed trains to confine the high braking ratios to the higher speeds where their full effectiveness is utilized.




## High Braking Ratios Used Only at High Speeds

Above 65 M.P.H. the Braking Ratio is 250%.

From 65 M.P.H. this Braking Ratio is gradually reduced to 200%.

From 40 M.P.H. the 200% Braking Ratio is gradually reduced to 150%.

From 20 M.P.H. the 150% Braking Ratio is gradually reduced to 100%.

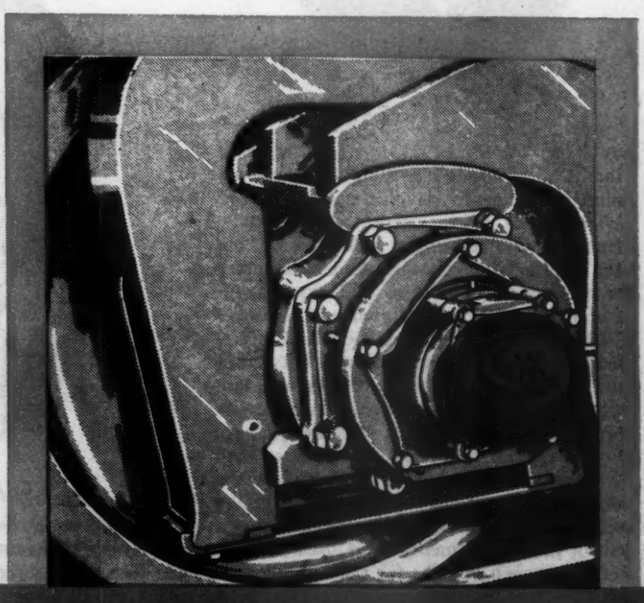
One Speed Governor per car is recommended in order to provide maximum flexibility with respect to train consist.

## Decelostat Control

Wheel slip protection can be associated with speed governor control.

## Smooth Stops From Any Speed

The gradual reduction in braking forces, proportional to speed change, maintains a uniform rate of retardation, eliminating surge generally associated with the stop.



COMPANY · Wilmerding, Penna.

AMERICAN CAR AND FOUNDRY COMPANY.—*Charles J. Hardy,* president of the American Car and Foundry Company, has relinquished part of his duties as the chief executive of that company, becoming chairman of

C. J. Hardy

the board, in which capacity he will direct and supervise the policies, finances, and activities of the company. Mr. Hardy retains his various offices and directorates in the companies controlled by or affiliated with the American Car and Foundry Company. *Frederick A. Stevenson,* senior vice-president in charge of the company's operations,

F. A. Stevenson

has been elected president to succeed Mr. Hardy. *Thomas F. Wilson* has been appointed assistant to Mr. Stevenson. *J. A. V. Scheckenbach,* whose election as a vice-president was reported in the January issue, has been appointed in charge of manufacturing for the company and also will have charge of improvements and maintenance. *Howard C. Wick,* secretary of the American Car and Foundry Company and various of its affiliates, has been appointed executive assistant to the executive committee, which office has been combined with that of secretary. *Heber D. Distelhurst, Howard C. Lunger* and *Benjamin W. Dodwell,* members of the sales department of the company, have been appointed assistants to the vice-president of that department. *L. A. Bedard,* formerly manager of sales for the Mount Vernon Car Manufacturing Company, has been appointed sales agent for the American Car and Foundry Company with headquarters at the St. Louis, Mo., sales office. *Harold P. Ackerman,* a member of the valve department of the company, has been appointed assistant manager of that department. *H. H. Pancake,* formerly engineer-mine car construction, has been transferred to the Pittsburgh, Pa., district sales office as sales engineer, and *J. F. Miller,* sales agent at Pittsburgh, has been transferred to the Berwick, Pa. plant in a sales capacity.

*Charles J. Hardy* received his education at the College of the City of New York and at Columbia University, from which latter institution he was graduated with a law degree. He was elected president of the American Car and Foundry Company in March, 1933, having previously served as one of the company's directors and for more than twenty-five years as its general counsel.

*Frederick A. Stevenson* began his career as an apprentice in the company's Detroit, Mich., shops more than forty years ago. He subsequently held the positions of master mechanic, assistant general manager, assistant vice-president in charge of operations, vice-president and senior vice-president. During the first war he was in charge of the Detroit, Buffalo and Depew, N. Y., plants which were engaged in the production of artillery vehicles, shells, etc. Currently, he has been in charge of all engineering and production involved in the company's emergency program, at the same time continuing to give attention to the current and postwar program regarding railroad equipment. The department of research and development was under his jurisdiction as senior vice-president, and the studies and plans under way for practical designs and construction of rail equipment will continue to receive his attention as president.

*L. A. Bedard,* sales agent at St. Louis, was a graduate from Purdue University with a degree in mechanical engineering in 1916. He began his business career with the Mount Vernon Car Manufacturing Company and held various positions in

L. A. Bedard

the engineering department until he was appointed assistant mechanical engineer. He was transferred to the sales department in 1936 and appointed manager of sales in 1937.

*Harold P. Ackerman,* assistant manager of the valve department, will be in charge of sales promotion in the eastern states and will be concerned with the development of new types of valves and other new products for manufacture in the postwar period. Mr. Ackerman began his career during school vacation periods in the engineering-

Harold P. Ackerman

drafting room of the Mesta Machine Company of Pittsburgh, Pa. Following service in the armed forces in 1918, he worked with the Arizona Highway Department from 1919 to 1923. He joined the Homestead Manufacturing Company as sales engineer in 1923 and continued with that organization until 1933, when he entered the valve department of the American Car and Foundry Company.

◆

GRAYBAR ELECTRIC COMPANY.—*Charles S. Powell,* manager of the communications and merchandising departments of the Graybar Electric Company, has been elected vice-president and a director of the company. Mr. Powell began his career with the Graybar company in 1914.

◆

AMERICAN STEEL & WIRE COMPANY.—*H. H. Smith,* works metallurgist of the Donora Steel & Wire Works, has been appointed assistant manager, metallurgical department of the American Steel & Wire Company, to succeed the late Lawrence H. Dunham. *R. A. Woodside,* a former division metallurgist, has been appointed works metallurgist of the Donora Works to succeed Mr. Smith.

◆

INTERNATIONAL NICKEL COMPANY.—*Dr. V. N. Krivobok,* former chief metallurgist of the Lockheed Aircraft Corporation and professor of metallurgy at the Carnegie Institute of Technology, has become associated with the development and research division of the International Nickel Company.

◆

PULLMAN-STANDARD CAR MANUFACTURING COMPANY.—A special wartime award for accident prevention was presented to the shipbuilding division of the Pullman-Standard Car Manufacturing Company by the National Safety Council on April 3. The presentation of a safety plaque and "S" flag was made by N. H. Dearborn,

executive vice-president of the National Safety Council at noontime ceremonies at the Calumet Harbor yards. He pointed out that despite a large increase in man-hours worked in 1943, the division held its frequency rate for deaths and permanent disabilities to 13 per cent of the average for its group and its rate for temporary disabilities to only 17 per cent. According to W. N. Barker, vice-president, the accident frequency rate of the division was 4.24, as compared with an average of 30.9 for 281 yards throughout the nation. Recently, the company won first place in the Great Lakes area in the 1943 Victory Shipbuilding Contest.

◆

H. K. Porter Company, Inc.—The H. K. Porter Company, Inc., Pittsburgh, Pa., has appointed three new district managers: *Joseph F. Gaffney,* Rochester, N. Y., serves northern New York; *R. W. Steves,* Cincinnati, Ohio, serves major portions of Ohio, Kentucky, West Virginia and Indiana; and *W. T. Campbell,* Philadelphia, Pa., covers western New Jersey, eastern Pennsylvania and Delaware. *J. L. Cunningham,* Union, N. J., has been appointed field service engineer, for the Chemical Process and Quimby Pump divisions in northern New Jersey, with headquarters at Newark, N. J.

◆

Pittsburgh Steel Foundry Corporation.—*E. S. Weidle,* general manager of sales for the Pittsburgh Steel Foundry Corporation, has been appointed vice-president in charge of sales and *Walter White,* plant manager, has been appointed vice-president in charge of production.

◆

Erwin, Wasey & Company, Ltd.—*George F. Endicott,* railway equipment designer and engineering consultant, has joined Erwin, Wasey & Company, Ltd., Chicago, as technical advisor. Mr. Endicott was graduated from Purdue University. For many years he was car and locomotive designer, assistant master car builder and mechanical engineer of the Northern Pacific at St. Paul, Minn. He later served with Hydraulic Controls, Inc., a division of the New York Air Brake Company.

◆

Climax Molybdenum Company.—*Robert S. Archer,* chief metallurgist, Chicago district for the Republic Steel Corporation, has been appointed metallurgical assistant to the vice-president of the Climax Molybdenum Company.

◆

Cleveland Pneumatic Tool Company.—*George P. Torrence,* vice-president and general manager of the Rayon Machinery Corporation, Cleveland, Ohio, has been elected president of the Cleveland Pneumatic Tool Company and its subsidiary, the Cleveland Pneumatic Aerol Inc., and *Daniel C. Green,* former president, has been elected chairman of the board of both companies. Mr. Torrence was formerly associated with the Link Belt Company of Chicago and was president of that company from 1932 to 1936. Mr. Green's service with the Cleveland Pneumatic Tool Company began in March, 1942, when he was elected a director and chairman of the board, which positions he took as a war assignment intending to return to the professional consulting field when his work was completed. He was elected president in June, 1943.

◆

Westinghouse Air Brake Company.—*C. D. Stewart,* chief engineer of the Westinghouse Air Brake Company, Wilmerding, Pa., has been appointed director of engineering. Mr. Stewart received his technical education at Pennsylvania State College and has been associated with the Westinghouse company since 1913. He served on the west coast as mechanical expert, with headquarters in San Francisco, Calif., and as district engineer and vice-president of the Westinghouse Pacific Coast Brake Company until his transfer to Wilmerding as chief engineer.

C. D. Stewart

*Ellis E. Hewitt* has been appointed chief engineer to succeed Mr. Stewart. Mr. Hewitt has been associated with the company for 33 years. He received his technical training at the Carnegie Institute of Technology and served in a succession of engineering positions, including chief design engineer, before being appointed assistant chief engineer in 1940.

Ellis E. Hewitt

◆

Tubular Alloy Steel Corporation.—Ceremonies dedicating the opening of the Gary, Ind., plant of the Tubular Alloy Steel Corporation, a subsidiary of the United States Steel Corporation, were held on April 5. The plant was developed at the suggestion of the Office of Production Management and under arrangements whereby Tubular Alloy owns the land, plant buildings and service facilities and leases all equipment, including machine tools, motors and production machinery, from the Defense Plant Corporation. The plant makes alloy seamless and stainless steel tubing.

◆

Timken Roller Bearing Company.—*James F. Reid,* former deputy chief of the alloy steel branch of the War Production Board, has been appointed production manager of the Timken Roller Bearing Company, Canton, Ohio. Mr. Reid had been production manager of the Steel and Tube division before joining WPB in 1942.

◆

Garlock Packing Company.—*Charles J. Anderson* has been appointed railroad representative of the Philadelphia, Pa., office of the Garlock Packing Company. Mr. Anderson began his career as an apprentice in the Schenectady, N. Y., shops of the American Locomotive Company. He became chief draftsman of the Locomotive Feed Water Heater Company in 1920 and assistant chief draftsman of the Franklin Railway Supply Company in 1923. Prior to becoming railroad representative of the Garlock Company he was chief draftsman of the Balmar Corporation, Baltimore, Md., with which organization he became associated in 1939 as estimating engineer.

## Obituary

Joseph T. Ryerson & Son.—*Fred S. Doran,* vice-president of Joseph T. Ryerson & Son, died March 24 in Chicago. Mr. Doran began his career with the company as an office boy in 1905. He represented the company in Wisconsin and southern Minnesota for a number of years and, in 1920, was appointed assistant sales manager of the Chicago plant. In 1927 he was appointed manager of the Ryerson Cleveland, Ohio, plant, and in 1941, was transferred to the general offices in Chicago to assume more general responsibilities in connection with the Ryerson war effort. He was elected vice-president in 1942.

Fred S. Doran

◆

Arthur C. Drynan, general manager of the railroad department of the International Correspondence Schools, died March 10, in Scranton, Pa.

◆

William S. Atwood, vice-president and a director of the Canadian Car and Foundry Company, died March 18. He was 68.

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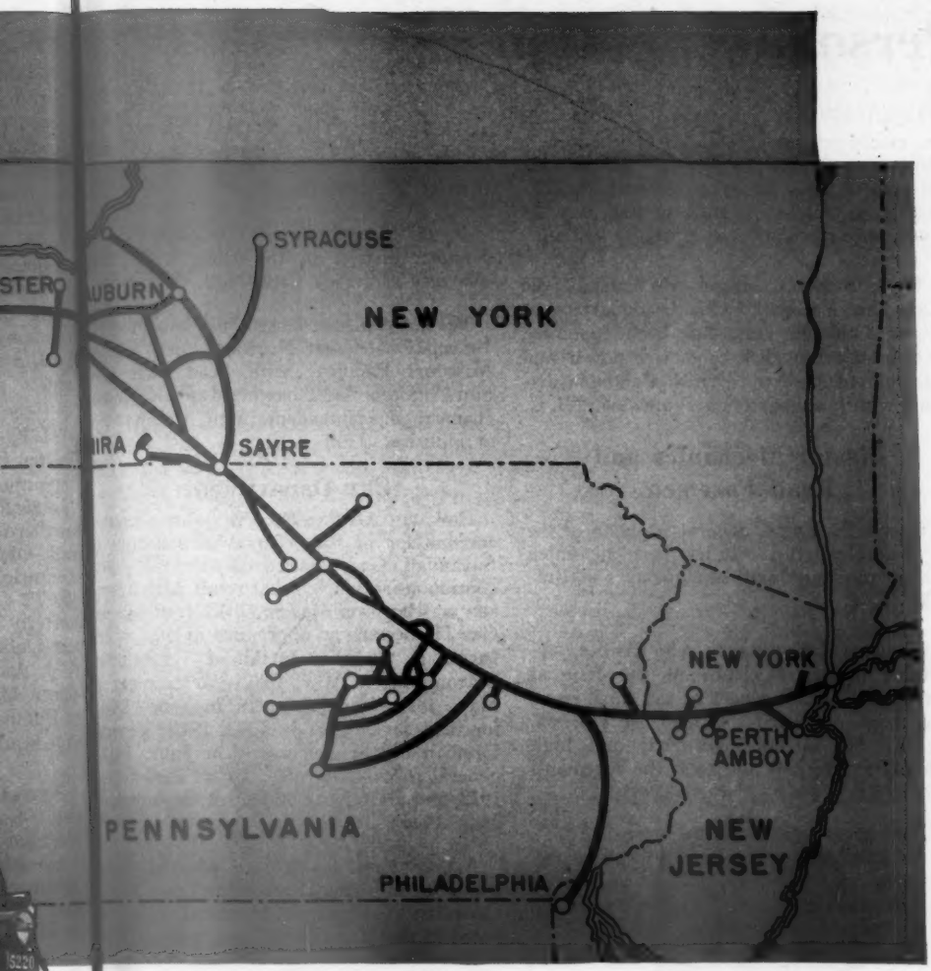
KEEPING PACE
with the
NATION'S NEEDS
ROCHESTER
BUFFALO
Buy War Bonds




**First introduced on the Lehigh Valley in 1931 — duplicated several times since — designed to operate from Sayre, Pa., to Buffalo, N. Y.; from Buffalo to Jersey City, N. J.; and back to Sayre, and haul 3000-ton trains with a minimum of helper service.**

**Ten of these 4-8-4's were delivered to the Lehigh Valley by Alco in 1943.**

## Locomotive Characteristics

| | | | |
|---|---|---|---|
| Weight on Drivers | 274,500 Lb. | Boiler Pressure | 255 Lb. |
| Weight of Engine | 451,000 Lb. | Tractive Power with Booster | 79,000 Lb. |
| Cylinders | 26 x 32 Ins. | Tender Capacity—Water | 20,000 Gals. |
| Diameter of Drivers | 70 Ins. | Tender Capacity—Fuel | 30 Tons |

**AMERICAN LOCOMOTIVE**

MANUFACTURERS OF MOBILE POWER
STEAM, DIESEL AND ELECTRIC LOCOMOTIVES, MARINE DIESELS, TANKS, GUN CARRIAGES & OTHER ORDNANCE

Alco

# Personal Mention

## General

I. L. HARPER, superintendent, system shops and enginehouse of the Lehigh Valley at Sayre, Pa., has been appointed superintendent of motive power.

C. J. QUANTIC, superintendent of motive power and car equipment of the British Columbia district of the Canadian National at Vancouver, B. C., has been granted a leave of absence because of ill health.

L. P. MICHAEL, chief mechanical engineer of the Chicago & North Western, with headquarters at Chicago, retired on April 21. Mr. Michael was born near Lowell, Ind., on April 21, 1874, and was a graduate in mechanical engineering from Purdue Uni-

L. P. Michael

versity on June 16, 1896. On June 21 of the same year he entered the service of the Louisville, New Albany & Chicago (now the Chicago, Indianapolis & Louisville), as a special helper apprentice. In November, 1896, he became a locomotive fireman in the employ of the Wabash, and from May, 1897, to November of the same year was a locomotive fireman on the L. N. A. & C. In the latter month he became a draftsman in the employ of the Cleveland, Cincinnati, Chicago & St. Louis (Big Four), with headquarters at Indianapolis, Ind., on which road he later served as shop-building inspector, machinist, air-brake foreman, enginehouse foreman and general foreman. In 1906 Mr. Michael was appointed leading locomotive draftsman of the Chicago & North Western, and two years later was advanced to the position of chief draftsman, with headquarters at Chicago. In February, 1920, he was appointed mechanical engineer, and in June, 1929, chief mechanical engineer.

GEORGE W. BOHANNON, who has resigned as mechanical engineer of the Duluth, Missabe & Iron Range at Duluth, Minn., to become assistant to the chief mechanical officer of the Chicago & North Western at Chicago as noted in the April issue, was born on December 2, 1902, at Duluth. He attended Cornell University (1920-1923) and the University of Minnesota (1924-1926) and holds the degree of B.S. in mechanical engineering. He became a draftsman in the employ of the Duluth, Missabe & Iron Range on August 19, 1926, and from October 1, 1927, to February 29, 1944, was mechanical engineer at Duluth.

P. J. SPROULE, master mechanic of the Canadian National, with headquarters at Sioux Lookout, Ont., has been appointed acting superintendent of motive power and car equipment of the British Columbia district, with headquarters at Vancouver, B. C.

## Master Mechanics and Road Foremen

GEORGE E. LUND, general foreman of the Erie at Meadville, Pa., has been appointed master mechanic with headquarters at Buffalo, N. Y.

CHARLES F. SCHWARTZ, who has been appointed master mechanic of the Erie at Avoca, Pa., as announced in the April issue, was born on April 28, 1895, at Hornell, N. Y. He attended grammar and high schools at Hornell and took the foreman's

C. F. Schwartz

course through the Railway Educational Bureau. He entered the employ of the Erie on June 10, 1910, as a machinist apprentice. He became journeyman machinist in 1914 and a machinist at Galion, Ohio, in 1915. He entered the U. S. Navy in 1917 and served with the Third Submarine Flotilla, Atlantic fleet, and on the U. S. S. Savannah until 1919, when he returned to Galion as a machinist. In 1920, he became fitting shop foreman at Galion; in 1922, machine shop foreman at Meadville, Pa.; in 1923, assistant general foreman at Hornell; in 1928, general foreman, nights, at Secaucus, N. J.; in 1929, general foreman, days, and on March 1, 1944, master mechanic at Avoca.

EDWARD POOL, master mechanic of the Western district of the Erie at Meadville, Pa., has been appointed master mechanic of the Eastern district, with headquarters at Jersey City, N. J.

C. K. JAMES, master mechanic of the Erie at Buffalo, N. Y., has been appointed district master mechanic of the Western district at Meadville, Pa.

F. H. MURRAY, master mechanic of the Eastern district of the Erie, with headquarters at Jersey City, N. J., has retired.

W. G. WILSON, master mechanic of the International-Great Northern (part of the Missouri Pacific), with headquarters at San Antonio, Tex., has been appointed mechanical superintendent, with headquarters at Houston, Tex.

## Car Department

EDWARD ALEXANDER ADAMSON, master car builder of the Central of Georgia at Savannah, Ga., has retired after 55 years continuous service on that road. Mr. Adamson was born on March 30, 1874, at Macon, Ga. He became an apprentice in the car department of the Central of Georgia at Macon, Ga., in May, 1889; car repairer in May, 1894; gang foreman in June, 1896; foreman car repairs in June, 1910; general foreman of car inspectors, in June, 1917; general foreman car department in October, 1918, and master car builder at Savannah in May, 1920.

ALLAN NEIL CAMPBELL, who has been appointed mechanical inspector (car) of the Canadian National at Montreal, Que., as noted in the March issue, was born at Wil-

A. N. Campbell

ton Grove, Ont. He was a graduate of Central Collegiate, London, Ont., in 1931 and of the London Normal School in June, 1933. He completed a course in mechanical engineering through the International Correspondence Schools in March, 1941. He entered the employ of the Canadian National in October, 1933, as a carman apprentice at London; was transferred as an apprentice to Mimico train yards in June, 1937, and to the Toronto, Ont., coach yards in January, 1938. He became acting apprentice instructor at Toronto in June, 1938; carman apprentice at Leaside steel car shops

(*Continued on second right-hand page*)

in September, 1938; carman apprentice at Fort Erie train yards in June, 1939; carman apprentice at London coach shops in September, 1939; car inspector at Windsor train yards in January, 1940; car foreman at Palmerston, Ont., in November, 1941; inspector, office of general superintendent motive power and car equipment at Toronto, in April, 1942; car foreman at Palmerston, Ont., in May, 1942; assistant car foreman, Fleet street repair tracks, Toronto, in February, 1943; assistant car foreman, Toronto coach yards in June, 1943, and mechanical inspector on the staff of the chief of motive power and car equipment at Montreal, on February 1, 1944.

## Shop and Enginehouse

FRANCIS WHITAKER, who has been appointed superintendent of shops of the New York, New Haven & Hartford at New Haven, Conn., as noted in the April issue, was born on July 29, 1896, in New Haven. He attended high school, and Northeastern University—Polytechnic School (1922). He entered the service of the New Haven on June 29, 1914, as a blueprint boy in the drawing room. A short time later became

Francis Whitaker

a draftsman in the mechanical engineer's office and in 1920, valuation inspector. From 1923 until 1939 he was inspector in the mechanical inspection department and general foreman inspector at Readville; Dover street enginehouse; New Haven shops, and Readville, Mass., shops. Mr. Whitaker became chief mechanical inspector at New Haven in 1939; assistant superintendent shops at Readville in 1940; assistant master mechanic, Boston division, in 1940, and assistant superintendent of shops at Readville in 1941.

W. E. LEHR, assistant superintendent, system shops and enginehouse, has been appointed superintendent, system shops and enginehouse, of the Lehigh Valley at Sayre, Pa.

## Obituary

JOHN W. LEMON, mechanical superintendent of the International-Great Northern (part of the Missouri Pacific), with headquarters at Houston, Tex., died at his home in that city on February 25. Mr. Lemon was born at Newton, Kan., on February 24, 1879. He entered railway service in the mechanical department of the Denver & Rio Grande Western at Pueblo, Colo., in 1900. On March 25, 1902, he went with the Missouri Pacific as a machinist at Hoisington, Kan., where he subsequently served as foreman, general foreman and master mechanic. In 1924 Mr. Lemon was appointed superintendent of shops, with headquarters at Sedalia, Mo., and in December, 1933, mechanical superintendent at Houston, Tex.

# Trade Publications

***Copies of trade publications described in the column can be obtained by writing to the manufacturers, preferably on company letterhead, giving title. State the name and number of the bulletin or catalog desired, when it is mentioned.***

CARBIDE-TIP CUTTING TOOLS.—Wendt-Sonis Company, Hannibal, Mo. Forty-eight-page Catalog No. 144. Lists as standard many cutting tools tipped with carbide—tools not adaptations of existing high-speed-tool designs but specially designed for carbide-tip construction, with the carbide inserts on all-round tools lengthened approximately 25 per cent.

◆

ELECTRICAL CONNECTORS.—Burndy Engineering Co., Inc., New York. Sixty-four-page catalog of indent type electrical connectors for wires and cables. Sleeve of this type of connector, after being slipped on cable, is indented by means of a special tool to make a permanent electrical and mechanical connection. Connectors available for both solid and stranded wire and made in a variety of forms for wire sizes from No. 22 to 2,000,000 c.m.

◆

ARMCO PRODUCTS.—The American Rolling Mill Company, Middletown, Ohio. Booklets on Design Data on High-Tensile Stainless Steel Sheets for Structural Purposes; Straight Chromium Grade Stainless Steels; Chromium Nickel Grade Stainless Steels; Sheet Metals for Tomorrow's Products; Galvanized Sheets—Properties, Uses and Fabricating Procedures; Useful Facts About Armco Zincgrip; Armco Paintgrip; and Aluminized Steel.

◆

WELDING AND CUTTING EQUIPMENT.—Victor Equipment Company, 844-54 Folsom street, San Francisco, Calif. "Victor Welding and Cutting Apparatus Unit Bulletin, Form 20." Pictorial presentation.

◆

BULLARD MULT-AU-MATIC.—The Bullard Company, Bridgeport 2, Conn. Eight-page bulletin descriptive of a new Mult-Au-Matic for mass production tooling on work as large as 34 in. in diameter.

◆

CHERRY BLIND RIVETS.—Cherry Rivet Company, 231 Winston street, Los Angeles 13, Calif. Thirty-six page illustrated manual descriptive of Cherry blind rivets, their installation, tools, and inspection.

◆

SIMPLEX JACKS.—Templeton, Kenly & Co., 1020 S. Central avenue, Chicago 44. Catalog No. 44, 60 pages. Illustrates and describes Simplex lever, screw and hydraulic jacks and gives dimensions and weights of sizes from 3 to 100 tons' capacity.

◆

BATTERY CHARGING.—Electric Storage Battery Company, Philadelphia 32, Pa. Bulletin 207 — Charging Equipment for Exide Batteries Motive Power Service. Describes two-rate and modified constant potential systems of charging with numerous diagrams, graphs, and tables.

◆

GAGES.—Continental Machines, Inc., 1301 Washington avenue, South, Minneapolis 4, Min. "How to Measure in Micro Inches"—a 20-page booklet for inspectors, machinists and plant engineers. Deals with fundamentals of precision measurements and their application. Describes briefly a new mobile inspection unit.

* * *

Clean and orderly storage of materials is encouraged on the Baltimore & Ohio—These views are of the material storage yard at the car repair track at Parkersburg, W. Va.

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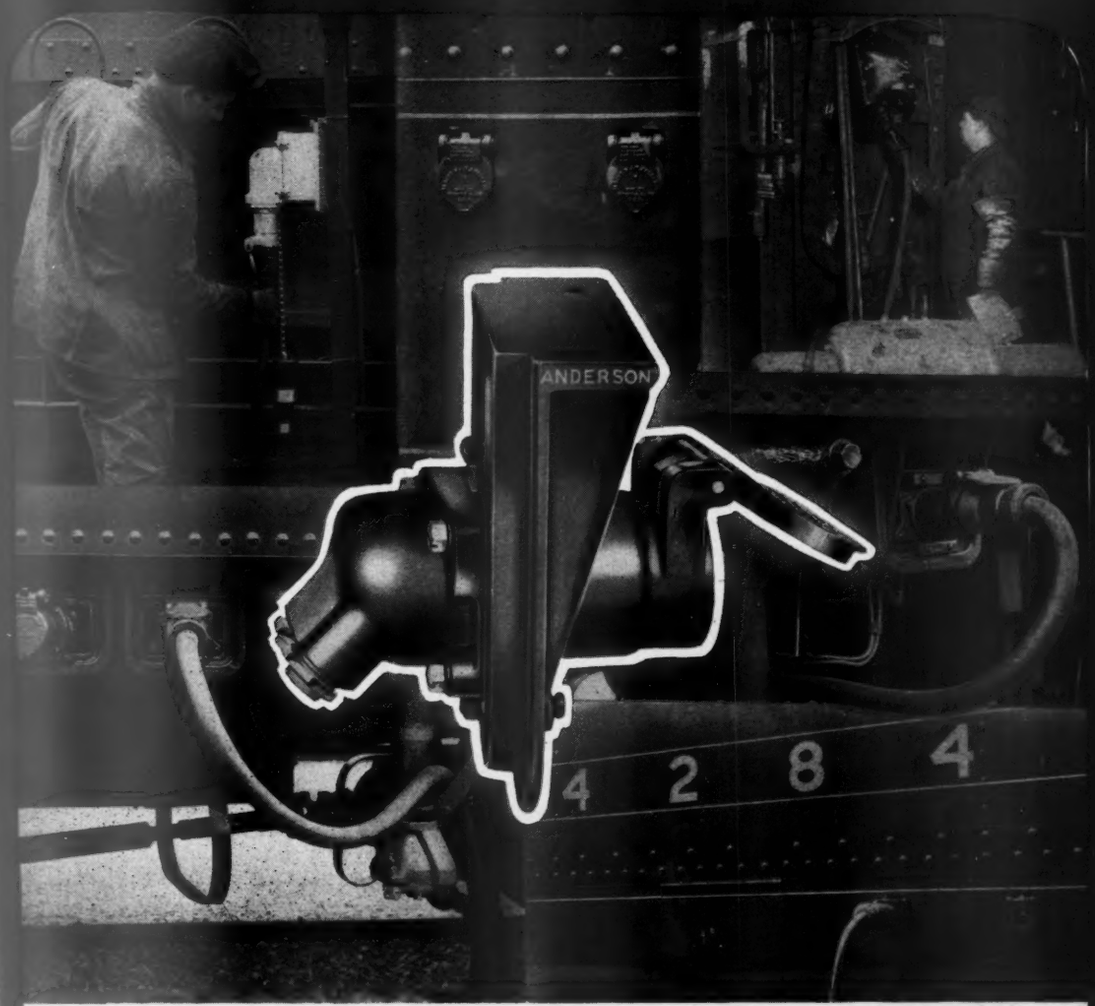


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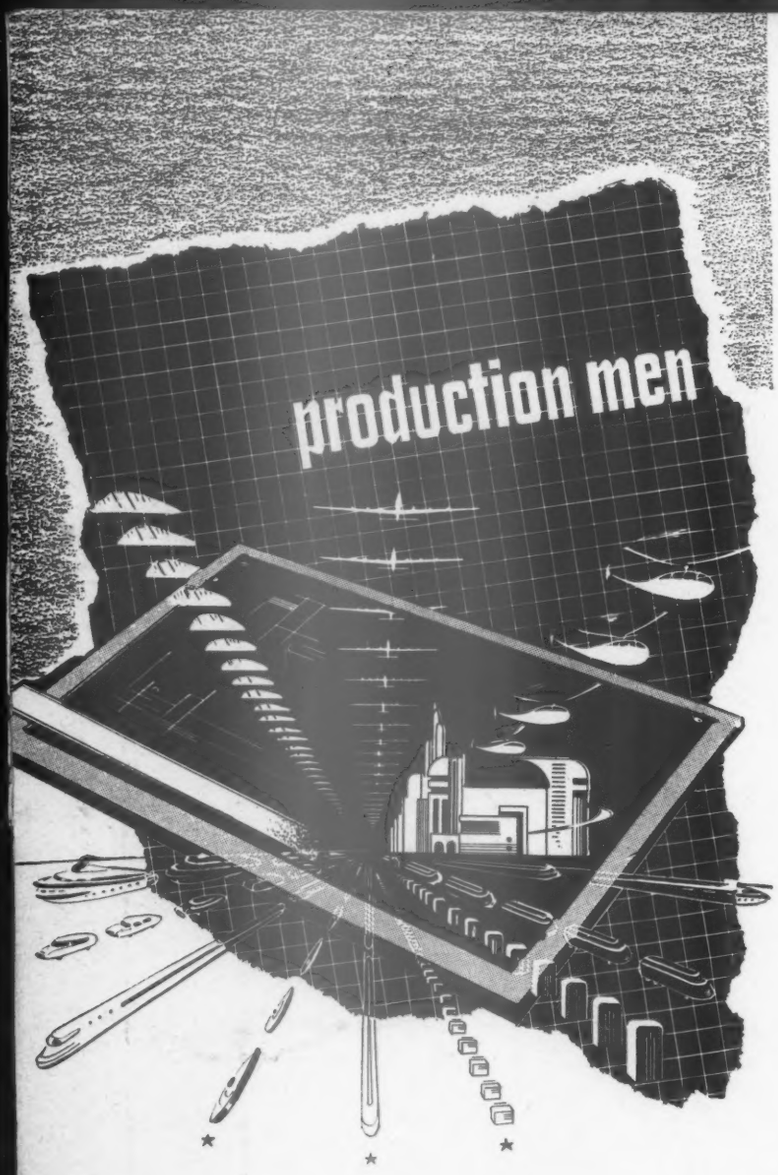


# must shape the peace, to

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Comes the peace and there will be those who will say: "It can't be done. We can't provide enough jobs. We can't keep all these wheels turning. The nation's productive capacity far exceeds all conceivable needs for the post war period."

The short-sighted won't see that world markets are but 60 hours — by air — from their shipping room door . . . who think it utopian that much better and much more can be made for far less . . . whose war production at any cost, today, blacks-out the need to blueprint "peacework" product production — and mass selling — at lowest cost, tomorrow.

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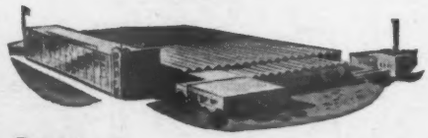

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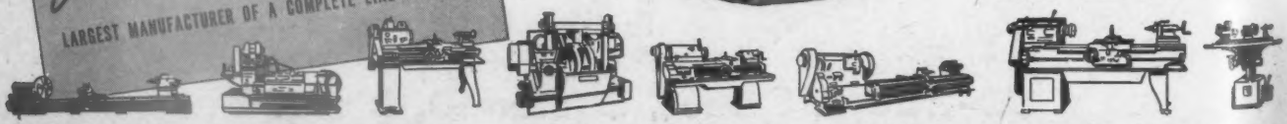

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